NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL MEMORANDUM

No. 1176

TEST REPORT ON THREE- AND SIX-COMPONENT MEASUREMENTS ON A SERIES OF TAPERED WINGS OF SMALL ASPECT RATIO

(Partial Report: Triangular Wing)

By Lange/Wacke

TRANSLATION

"Prüfbericht über 3- und 6-Komponentenmessungen an der Zuspitzungsreihe von Flügeln kleiner Streckung (Teilbericht: Dreieckflügel)"

Deutsche Luftfahrtforschung, Untersuchungen und Mitteilungen Nr. 1023/5

Washington

May 1948

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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TEST REPORT ON THREE- AND SIX-COMPONENT MEASUREMENTS ON A SERIES OF TAPERED WINGS OF SMALL ASPECT RATIO*

(Partial Report: Triangular Wing)

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The investigations of the reports UM 1023/1 to 4 on wings of small aspect ratio are continued. The present report deals with the results of the three- and six-component measurements and the flow pictures of the triangular wing series with the aspect ratio $\Lambda = 3$ to $\Lambda = 1$.

Rolling moment: x_e-axis = line of intersection of the vertical plane of symmetry of the body and the horizontal plane of the wind tunnel (positive toward flow direction).

Pitching moment: y_e-axis = lateral axis (along the wing)(positive leftward seen in flow direction).

Yawing moment: z_e-axis = normal axis (to wind direction)(positive downwash).

All moments viewed in direction of their positive axes of rotation are positive for clockwise rotation.

The coefficients of the forces and moments are:

A lift (kg)

W drag (kg)

Q lateral force (kg)

L rolling moment (mkg)

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*"Prüfbericht über 3- und 6-Komponentenmessungen an der Zuspitzungsreihe von Flügeln kleiner Streckung (Teilbericht: Dreieckflügel)." Zentrale für wissenschaftliches Berichtswesen über Luftfahrtforschung des Generalluftzeugmeisters (ZWB), Berlin-Adlershof, Untersuchungen und Mitteilungen Nr. 1023/5, Sept. 27, 1943.

M pitching moment (mkg)

N yawing moment (mkg)

$c_a = \frac{A}{q \times F}$ lift coefficient

$c_w = \frac{W}{q \times F}$ drag coefficient

$c_q = \frac{Q}{q \times F}$ lateral-force coefficient

$c_L = \frac{L}{q \times F \times \frac{b}{2}}$ rolling-moment coefficient

$c_M = \frac{M}{q \times F \times l_m}$ pitching-moment coefficient

$c_N = \frac{N}{q \times F \times \frac{b}{2}}$ yawing-moment coefficient

Angles:

α = angle of attack — angle between wing-fixed longitudinal axis and x_e-axis at rotation about the y_e-axis

β = angle of yaw — angle between wind-fixed longitudinal axis and x_e-axis rotation about the z_e-axis

These angles viewed in direction of the positive axes of rotation are positive for clockwise rotation.

Reference quantities:

F wing area (m^2)

b wing span (m)

$l_m = \frac{F}{b}$ mean chord (reference chord (m))

$q = \frac{\rho}{2} v^2$ dynamic pressure (kg/m^2)

Model dimensions:

Wing FD	Wing ED	Wing DD	Wing CD
$\Lambda = 3$	$\Lambda = 2$	$\Lambda = \frac{4}{3}$	$\Lambda = 1$
$F = 0.75\ m^2$	$F = 0.75\ m^2$	$F = 0.75\ m^2$	$F = 0.75\ m^2$
$b = 1.500$ m	$b = 1.225$ m	$b = 1$ m	$b = 0.866$ m
$l_m = \frac{F}{b} = 0.5$ m	$l_m = \frac{F}{b} = 0.6125$ m	$l_m = \frac{F}{b} = 0.75$ m	$l_m = \frac{F}{b} = 0.866$ m

RESULTS

The results are consolidated in table A of this report, from which the curves and tables relating to the different wings can be taken.

In general, it was found that on the wings with aspect ratio $\Lambda = 3$ the flow conditions are radically different from those on wings of great aspect ratio. According to the measurements the lower limit lies at aspect ratio $\Lambda = 3$, which undoubtedly still belongs to the wings for which Prandtl's airfoil theory is applicable.

(a) Three-component measurements.- The results are represented in the charts 1, 7, 13, and 19 as $c_a = f(\alpha)$, $c_a = f(c_w)$, and $c_a = f(c_M)$. The effectiveness c_a' decreases, as expected, with decreasing aspect ratio and increasing sweepback. For the wings with $\Lambda = \frac{4}{3}$ and $\Lambda = 1$, c_a' starts to increase from $c_a = 0.4$ on. This is due to the fact that in the rear part of the wing toward the tips a strong lateral flow is developed (see flow photographs) which results in lift-increasing low pressures.

The neutral point for all wings lies before the selected moment reference point, which lies $3/4 l_m$ ahead of the trailing edge. While for wing FD, $\Lambda = 3$ the $\frac{dc_M}{dc_a}$ is constant over the entire c_a range, the wings $\Lambda \leq 2$ exhibit a marked backward displacement of the neutral point. The c_a-value at which this backward shift begins, decreases

with decreasing aspect ratio and increasing sweepback. The cause of the stabilization is likewise attributable to the cited lateral flow at the rear part of the wing. The $c_{a_{max}}$ increases with decreasing aspect ratio and increasing sweepback, with $\alpha c_{a_{max}}$ being almost constant. The wing FD $\Lambda = 3$ falls outside this classification.

(b) Six-component measurements.- Lift, drag, and pitching moment referred to yawed flow, vary very little. Only at great angles of attack a slight decrease is to be noted. The neutral point travels slightly backward. For lateral force, rolling and yawing moment with respect to aspect ratio and sweepback, no particular systemization was to be found. A substantial effect on the lateral force and the rolling moment is certainly exerted by the previously mentioned lift-increasing lateral flow. The yawing moment is largely dependent upon the body drag of the wing leading edge and increases considerably with the sweepback.

FURTHER REPORTS OF THE SERIES

	UM No.
Trapezoidal wing $\left(\Lambda = \frac{4}{3}\right)$	1023/1
Trapezoidal wing with fuselage	1023/2
Elliptical wing $\Lambda = 2 + 1$	1023/3
Elliptical wing with fuselage	1023/4
Triangular wing with fuselage	1023/6

The entire test data with regards to the theory of a wing with small aspect ratio is being readied by Voepel.

Translated by J. Vanier
National Advisory Committee
for Aeronautics

TABLE A

SURVEY OF THE THREE- AND SIX-COMPONENT MEASUREMENTS

ON THE SERIES OF TAPERED WING (TRIANGULAR WING)

Symbol		Angle		Chart of curves	Table
		α°	β°		
FD $\Lambda = 3$	Three-component measurement	Variable	0	1	1
	Six-component measurement	0.39	Variable	2	2
	Do----	6.63	---do---	3	2
	Do----	13.56	---do---	4	3
	Do----	23.91	---do---	5	3
	Do----	25.89	---do---	6	4
ED $\Lambda = 2$	Three-component measurement	Variable	0	7	5
	Six-component measurement	0.40	Variable	8	6
	Do----	8.63	---do---	9	6
	Do----	16.86	---do---	10	7
	Do----	24.96	---do---	11	7
	Do----	35.55	---do---	12	8
DD $\Lambda = \frac{4}{3}$	Three-component measurement	Variable	0	13	9
	Six-component measurement	0	Variable	14	10
	Do----	10.63	---do---	15	10
	Do----	19.86	---do---	16	11
	Do----	29.89	---do---	17	11
	Do----	36.76	---do---	18	12
CD $\Lambda = 1$	Three-component measurement	Variable	0	19	13
	Six-component measurement	0	Variable	20	14
	Do----	13.03	---do---	21	14
	Do----	22.38	---do---	22	15
	Do----	31.67	---do---	23	15
	Do----	34.89	---do---	24	16

TABLE A - Concluded

SURVEY OF THE THREE- AND SIX-COMPONENT MEASUREMENTS ON THE SERIES OF TAPERED WING (TRIANGULAR WING) - Concluded

Symbol	Angle		Chart of curves	Table
	α°	β°		
Comparative curves of the four wings				
$c_a = f(\alpha)$; $c_a = f(c_w)$	Variable	0	25	
$c_a = f(c_M)$	Variable	0	26	
c_L and $c_q = f(\beta)$	$\alpha c_a = 0.3$	Variable	27	
c_L and $c_q = f(\beta)$	$\alpha c_a = 0.9$	Variable	28	

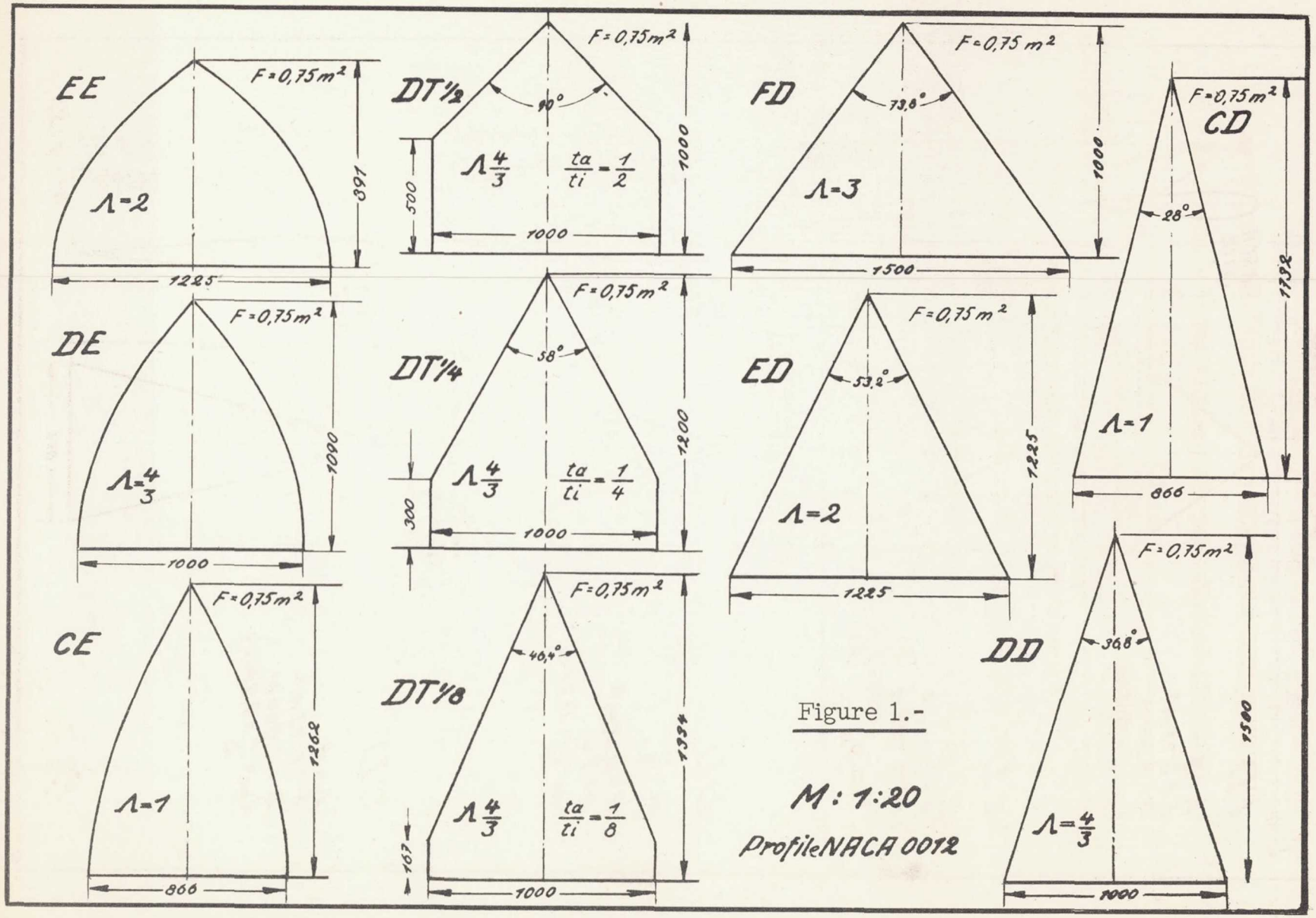


Figure 1.-

M: 1:20

Profile NACA 0012

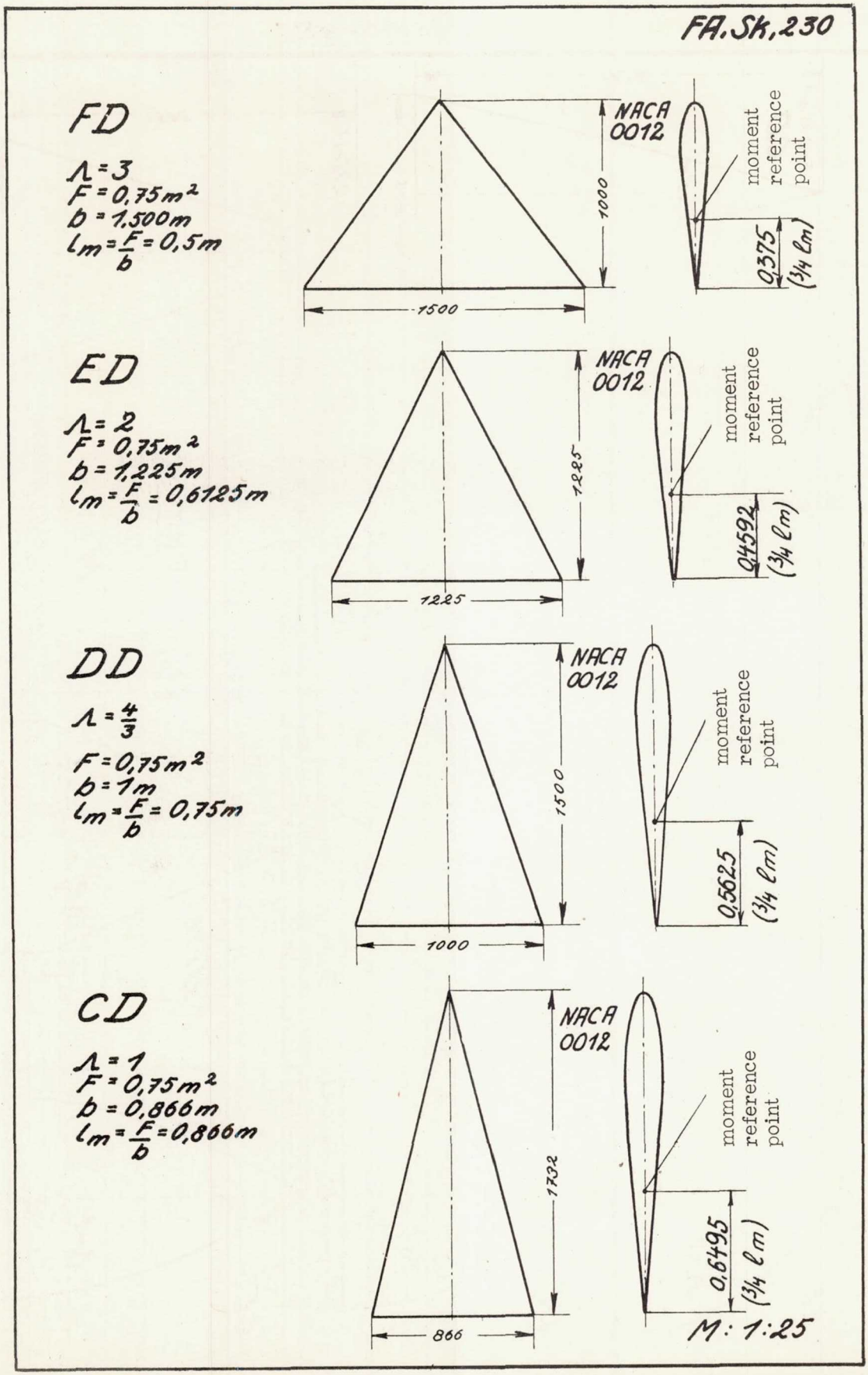
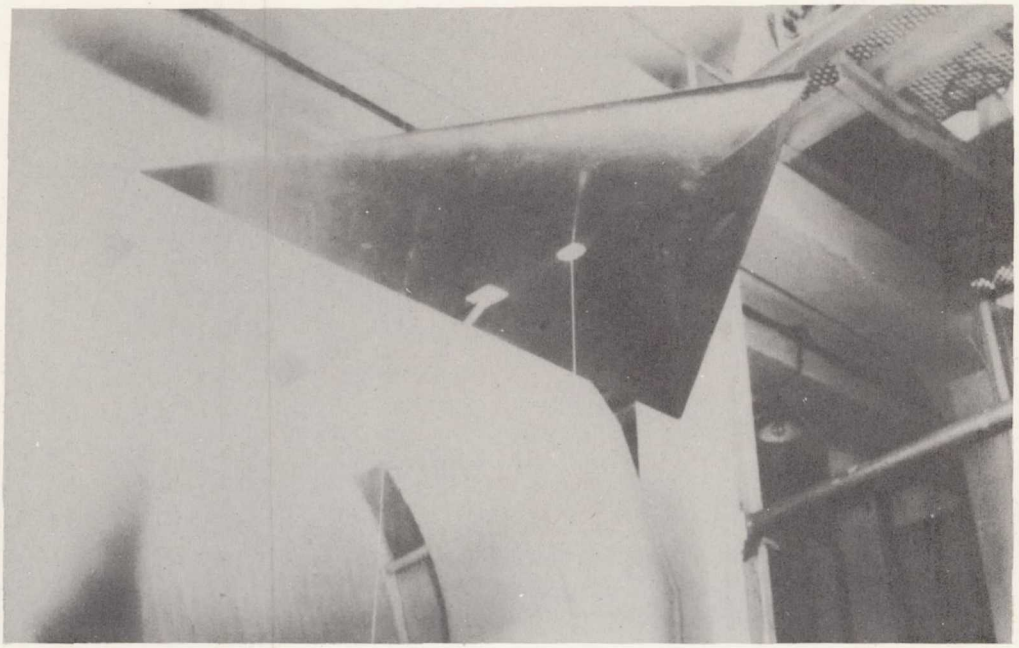
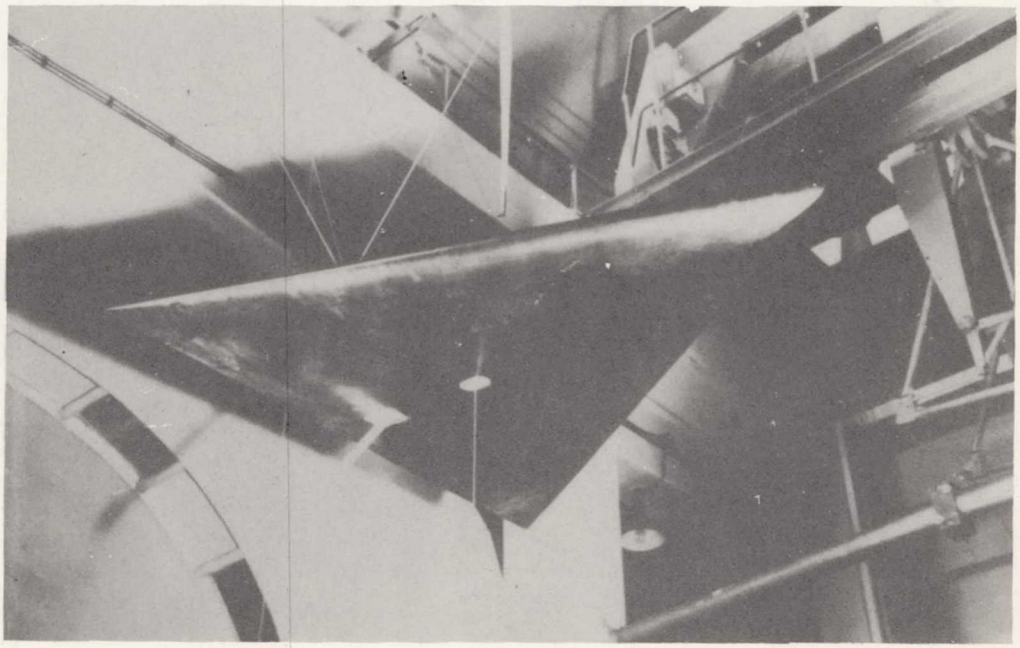

FA.Sk,230
FD
Λ = 3
F = 0,75 m²
b = 1,500 m
lm = F/b = 0,5 m
1500
1000
NACA 0012
moment reference point
0375 (¾ lm)
ED
Λ = 2
F = 0,75 m²
b = 1,225 m
lm = F/b = 0,6125 m
1225
1225
NACA 0012
moment reference point
04592 (¾ lm)
DD
Λ = 4/3
F = 0,75 m²
b = 1 m
lm = F/b = 0,75 m
1000
1500
NACA 0012
moment reference point
0,5625 (¾ lm)
CD
Λ = 1
F = 0,75 m²
b = 0,866 m
lm = F/b = 0,866 m
866
1732
NACA 0012
moment reference point
0,6495 (¾ lm)
M: 1:25

Figure 2.-



FDΛ = 3

Figure 3.- Suspension of the wing in wind tunnel.



EDΛ = 2

Figure 4.- Suspension of the wing in wind tunnel.

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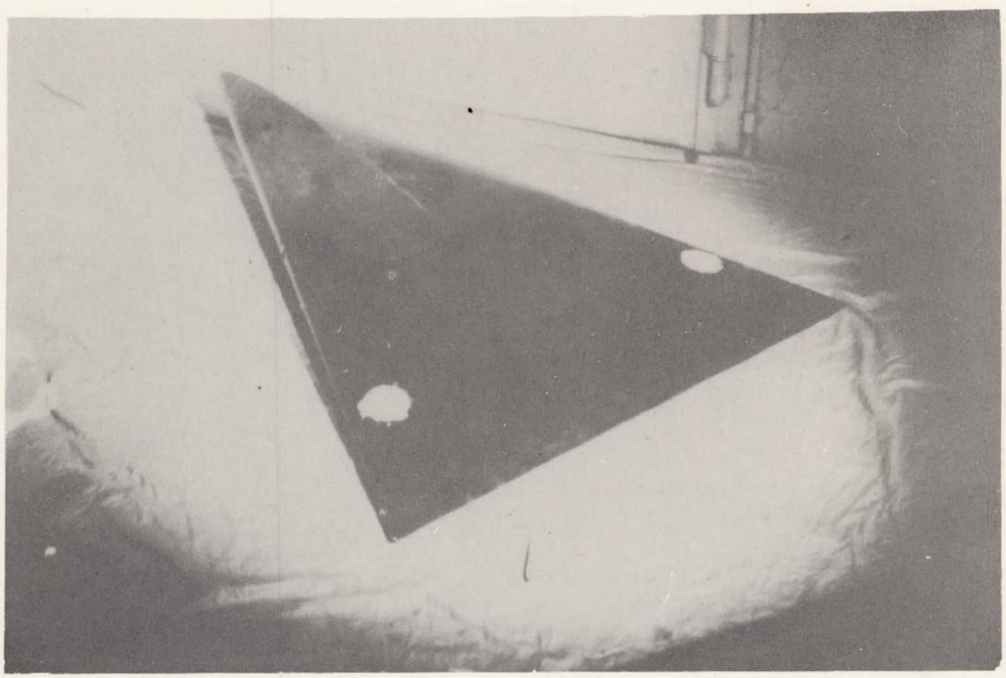
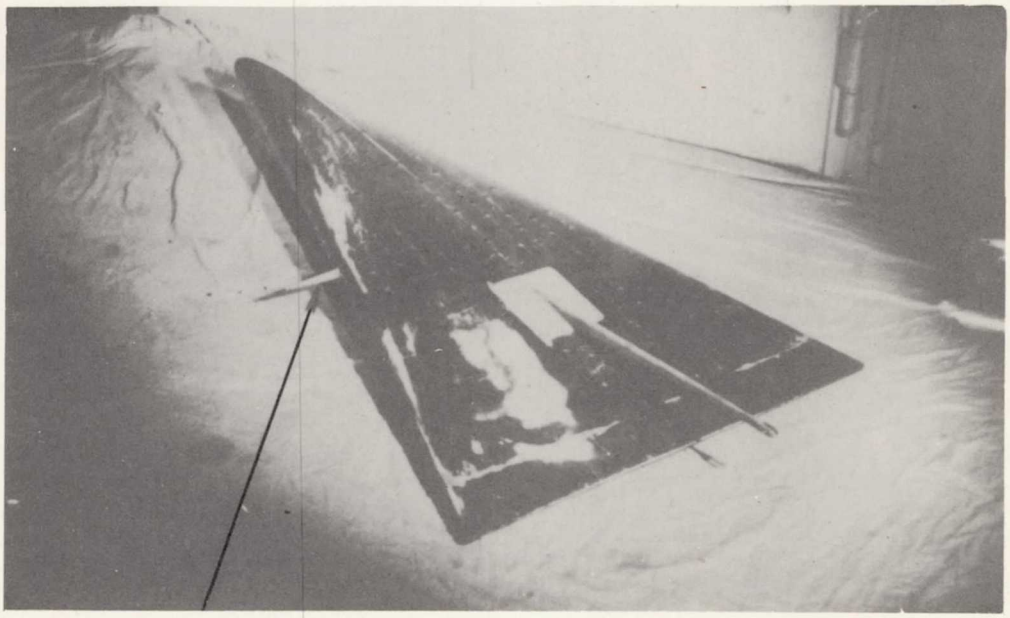


Figure 5.- DDΛ = 4/3.



Circular rod for arrangement of the frontal suspension points.

Figure 6.- CDΛ = 1.

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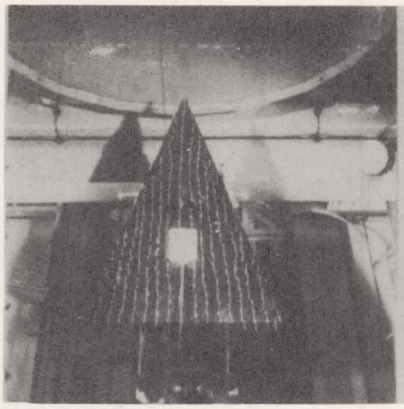
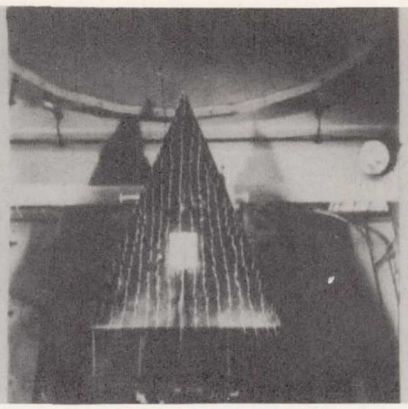
Flow photographs on the triangular wing - DD, Λ = 4/3 of the taper series.



$\alpha = 0°$



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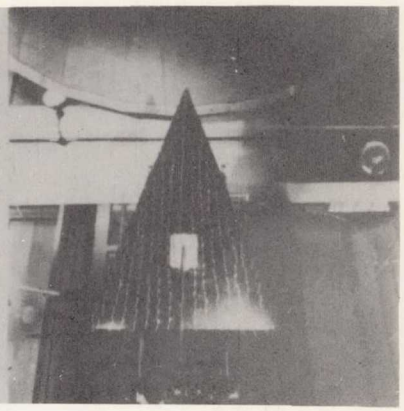

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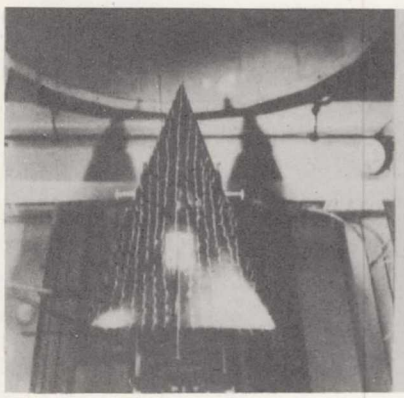
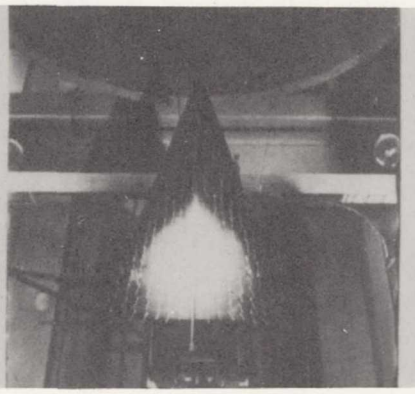
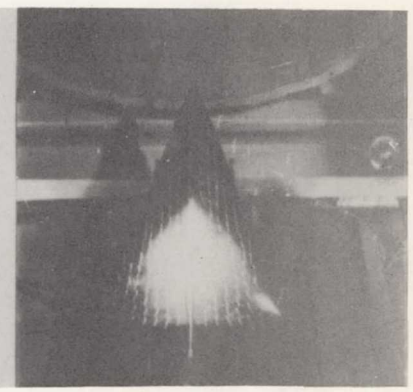


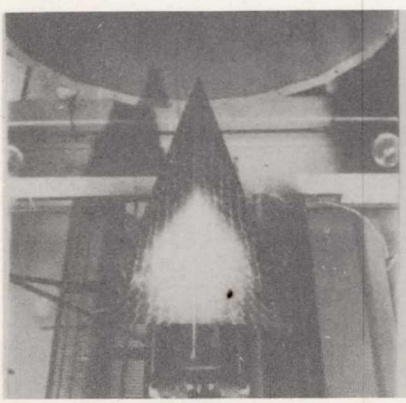
$\alpha = 9°$



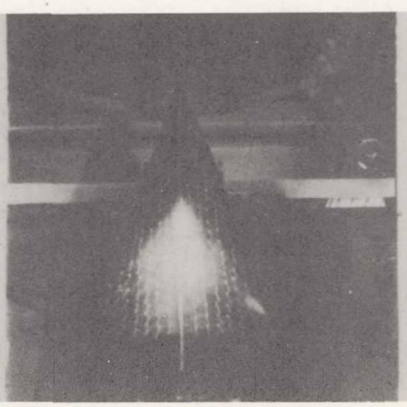
$\alpha = 10°$



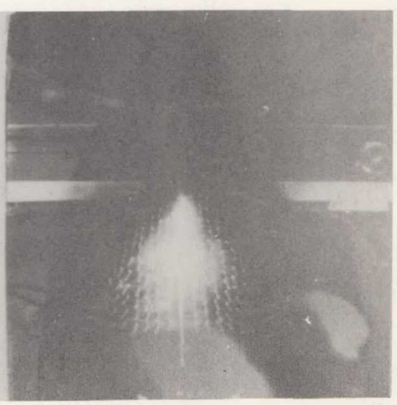
$\alpha = 11°$



$\alpha = 12°$



$\alpha = 13°$



$\alpha = 14°$

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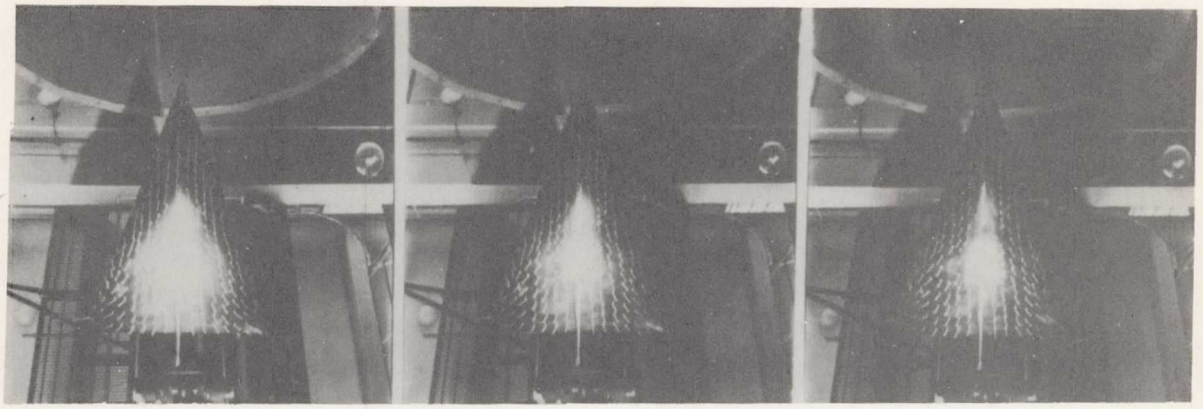
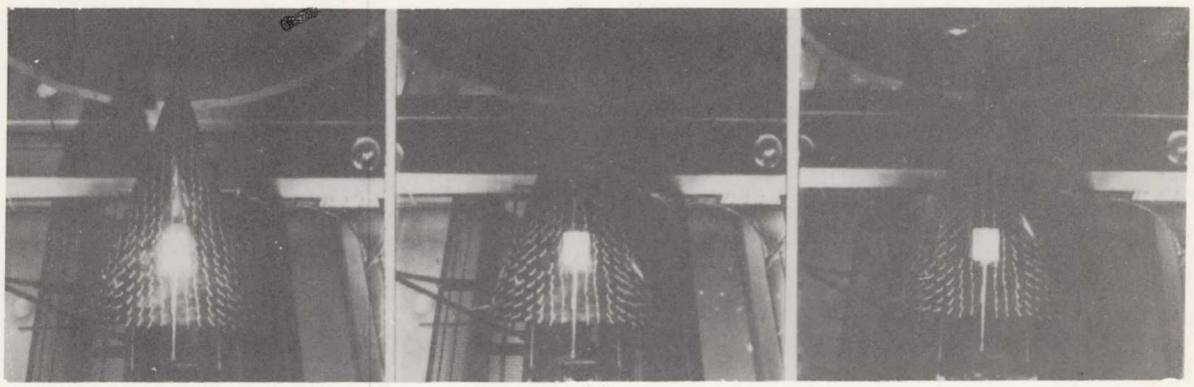
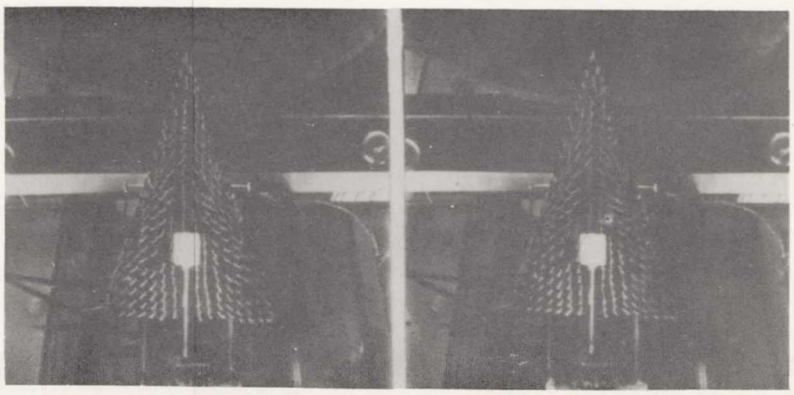
Flow photographs on the triangular wing - DD,Λ = 4/3 of the taper series.



$\alpha = 15°$ $\alpha = 16°$ $\alpha = 18°$



$\alpha = 20°$ $\alpha = 25°$ $\alpha = 30°$



$\alpha = 35°$ $\alpha = 40°$

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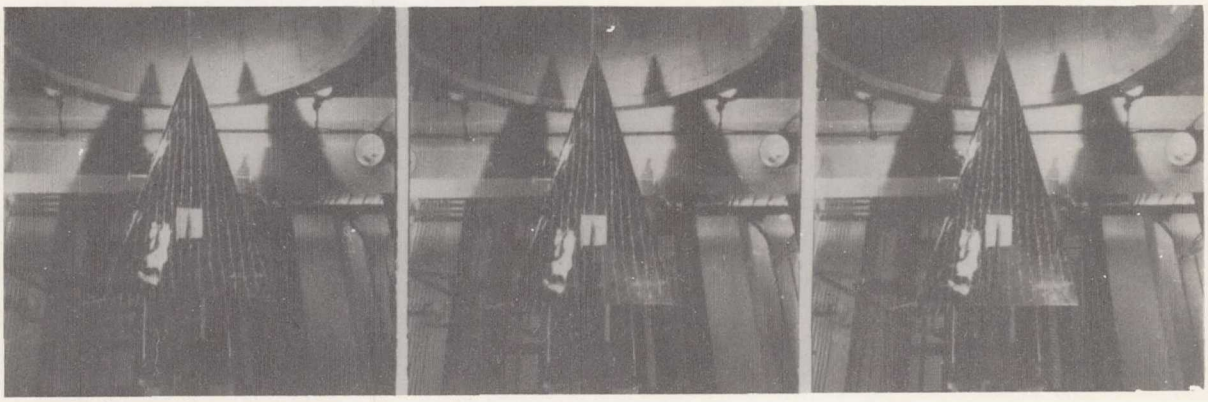
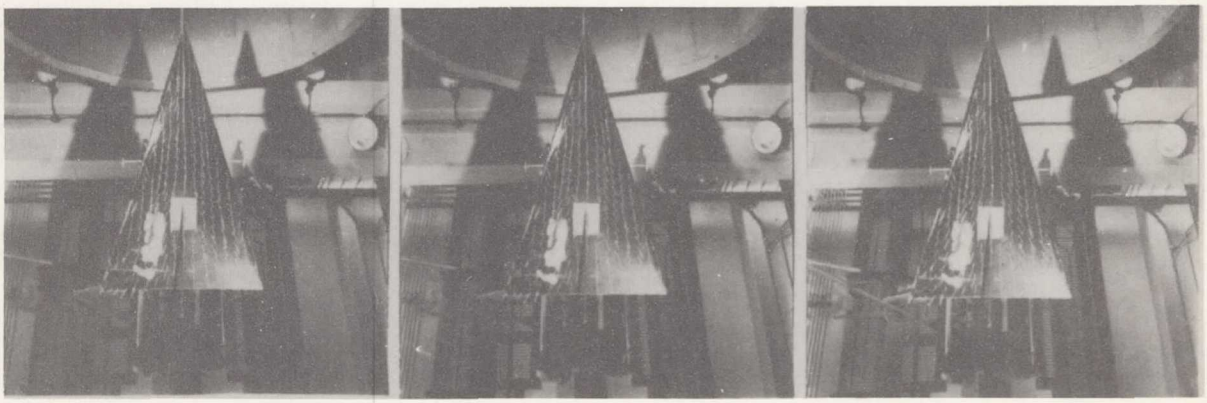
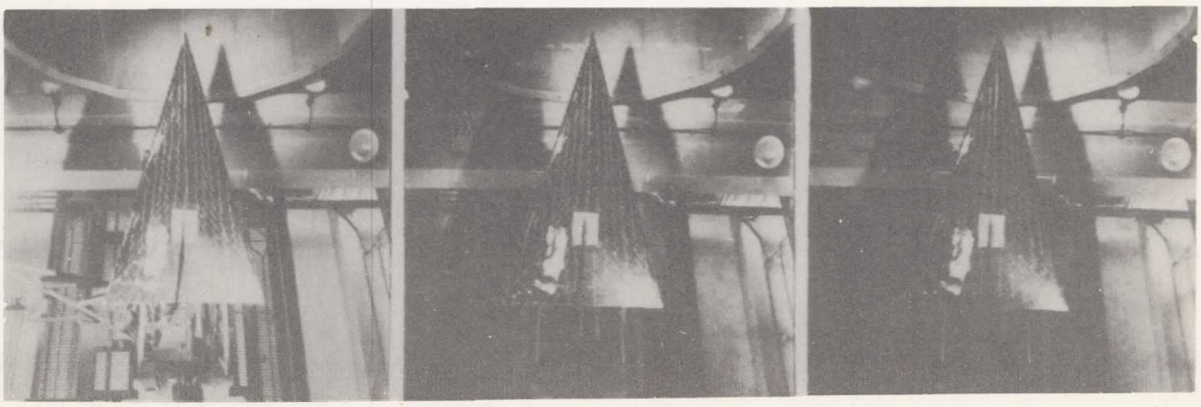
Flow photographs on the triangular wing - CD,Λ = 1 of the taper series.



$\alpha = 0°$ $\alpha = 5°$ $\alpha = 7°$



$\alpha = 9°$ $\alpha = 10°$ $\alpha = 11°$



$\alpha = 12°$ $\alpha = 13°$ $\alpha = 14°$

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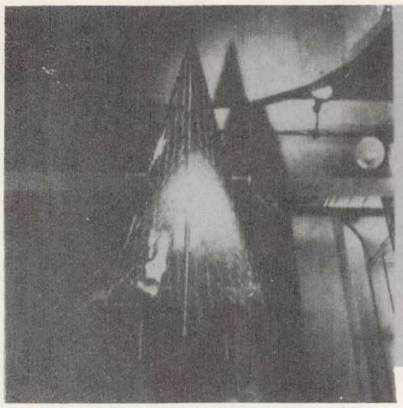
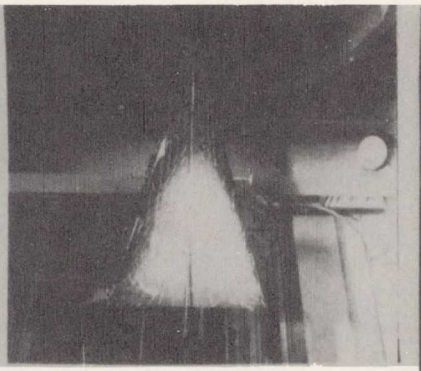
Flow photographs on the triangular wing - CD,Λ = 1 of the taper series.



$\alpha = 15°$



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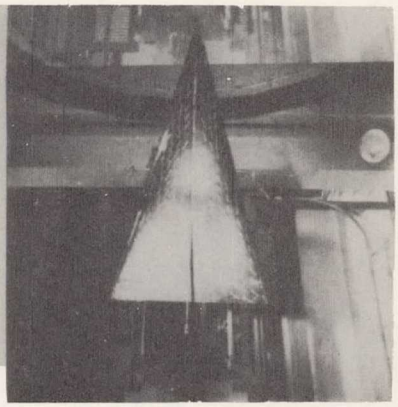
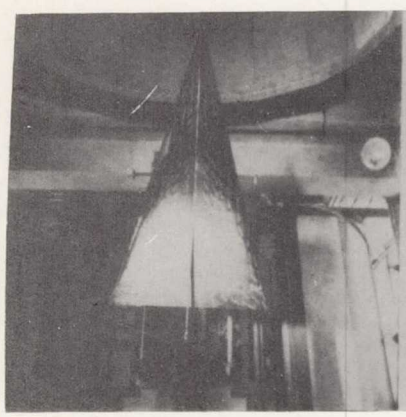


$\alpha = 18°$



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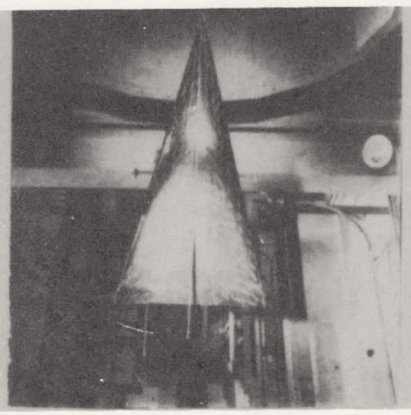

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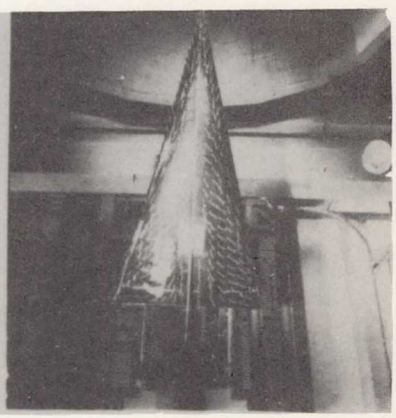

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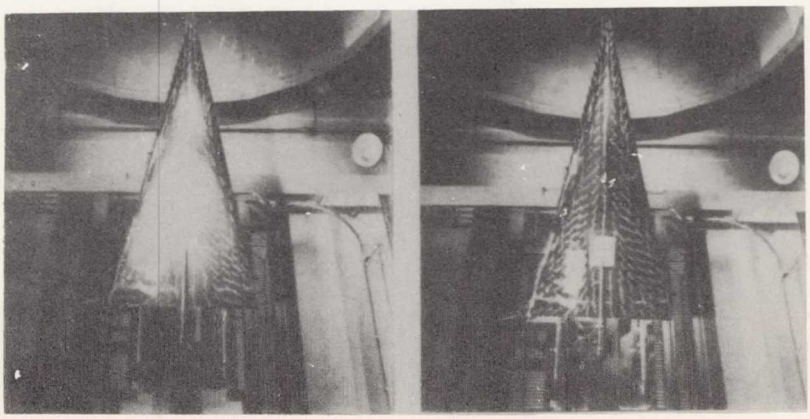

$\alpha = 35°$

$\alpha = 40°$

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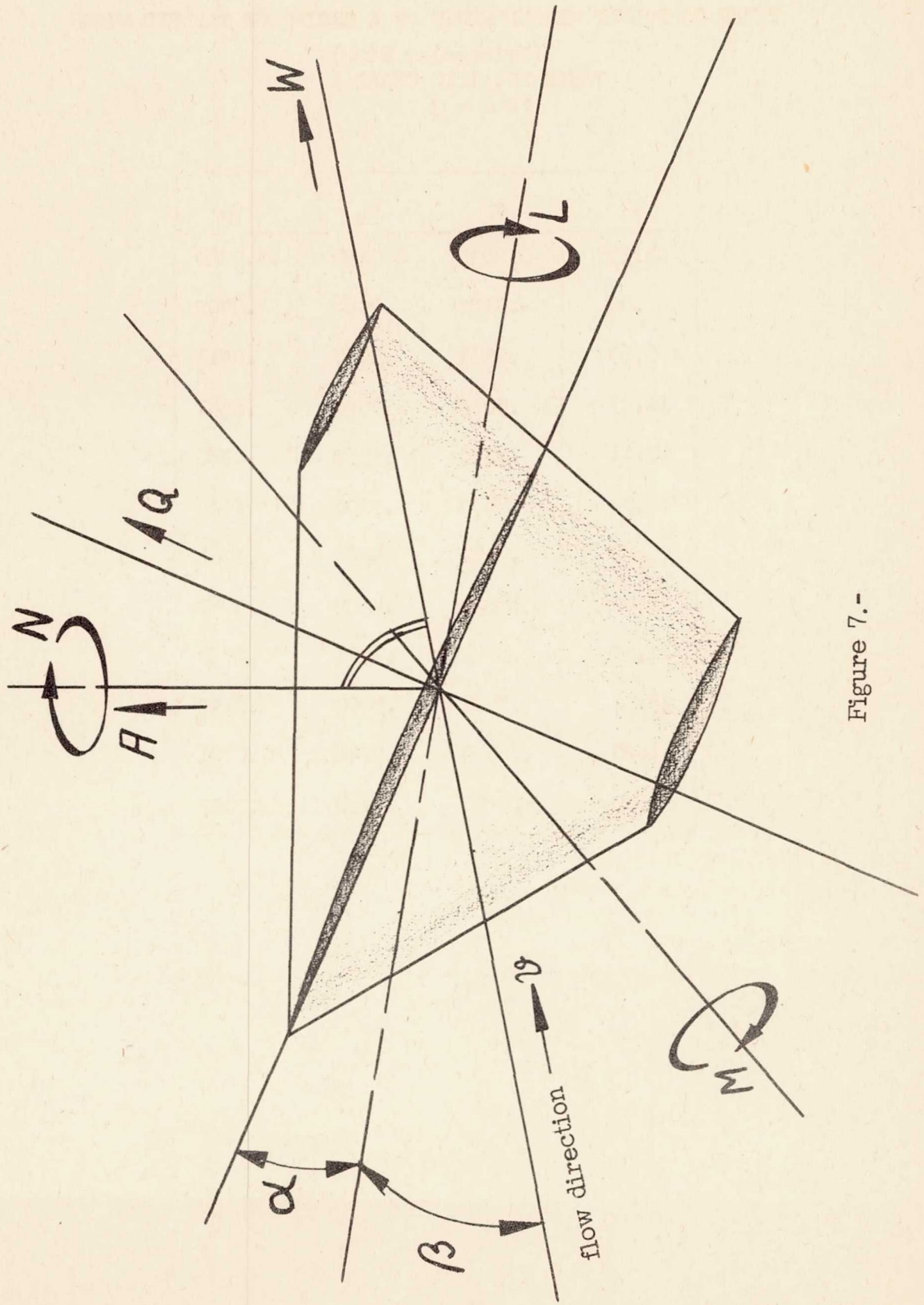

Figure 7.-

THREE-COMPONENT MEASUREMENTS OF A SERIES OF TAPERED WINGS

(Triangular Wing)
TABLE NO. 1 TO CHART 1
FD Λ = 3

α^{o}	c_a	c_w	c_M
-5.65	-0.2830	0.0195	-0.0285
.02	-.0152	.0068	.0002
5.69	.2561	.0157	.0311
11.37	.5115	.0534	.0647
17.11	.7275	.1529	.0980
22.92	.8843	.3200	.1102
25.82	.9152	.4081	.1064
28.92	.8830	.4689	.0881
32.02	.8042	.4921	.0730
35.07	.7587	.5090	.0733
41.20	.6525	.5246	.0391
.02	-.0156	.0068	.0003

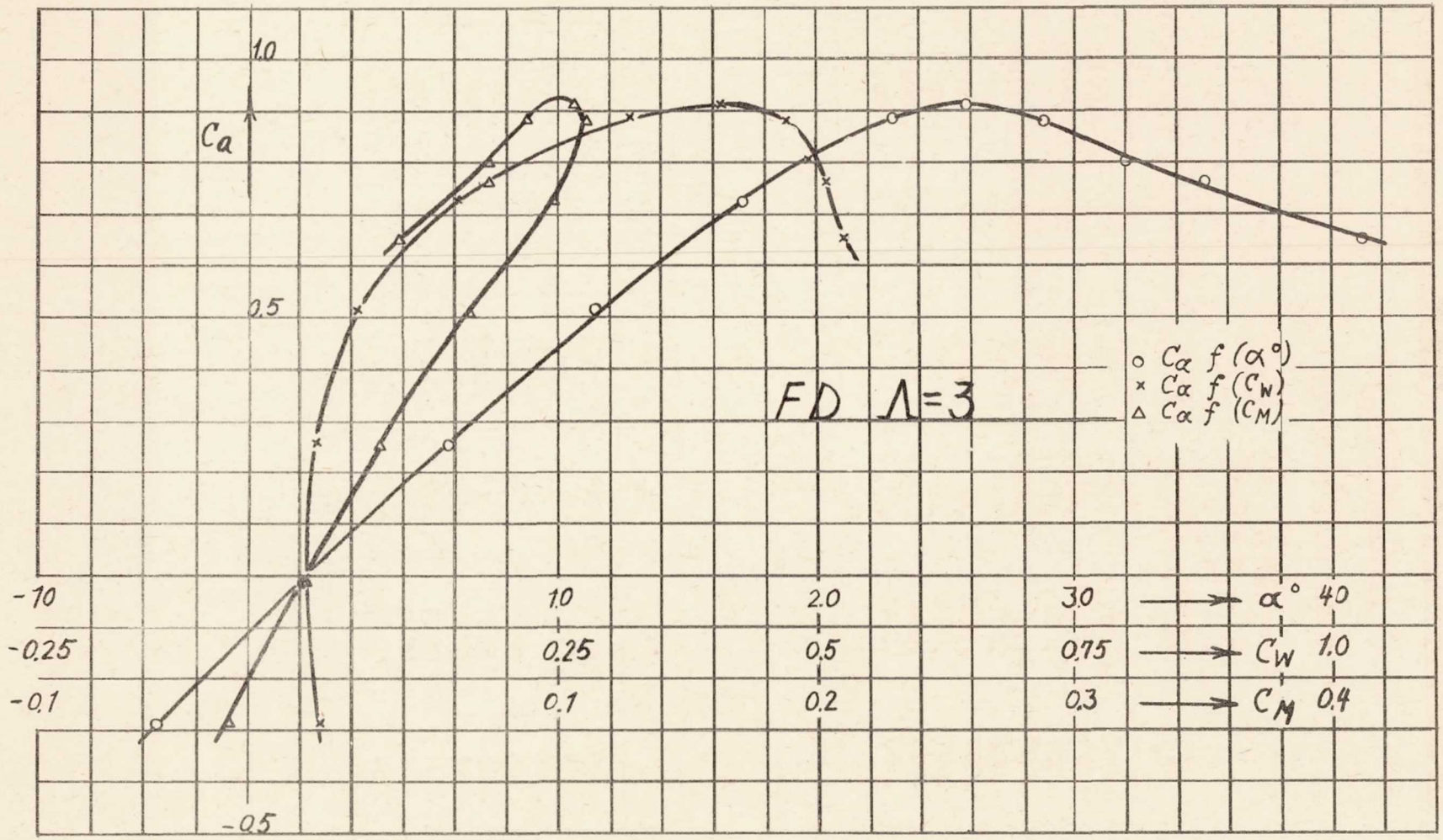

Chart 1.- 3-component measurement of a series of
Table 1.- tapered wings - triangular wings.

SIX-COMPONENT MEASUREMENTS OF A SERIES OF TAPERED WINGS

(Triangular Wing)

TABLE NO. 2 TO CHARTS 2,3

FD $\Lambda = 3$
$\alpha = 0.39^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
-4	0.008	-0.0033	0.0073	0.0012	0.0028	0.0012
-2	.007	-.0027	.0068	.0006	.0031	.0004
0	.007	-.0013	.0067	.0006	.0027	0
2	.008	0	.0068	.0012	.0024	-.0010
4	.008	.0013	.0071	.0013	.0024	-.0013
6	.007	.0027	.0073	.0007	.0027	-.0014
10	.007	.0040	.0083	.0007	.0027	-.0018
15	.006	.0060	.0095	.0009	.0024	-.0018
20	.006	.0080	.0109	.0009	.0024	-.0018

$\alpha = 6.63^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
-4	0.304	-0.0027	0.0200	-0.0094	0.0373	0.0027
-2	.304	-.0013	.0198	-.0050	.0376	.0010
0	.305	0	.0198	-.0006	.0369	.0001
2	.305	.0013	.0201	.0037	.0369	-.0015
4	.304	.0027	.0201	.0076	.0363	-.0023
6	.302	.0027	.0203	.0126	.0362	-.0031
10	.294	.0033	.0206	.0207	.0358	-.0050
15	.281	.0040	.0213	.0300	.0352	-.0069
20	.264	.0060	.0218	.0394	.0331	-.0080

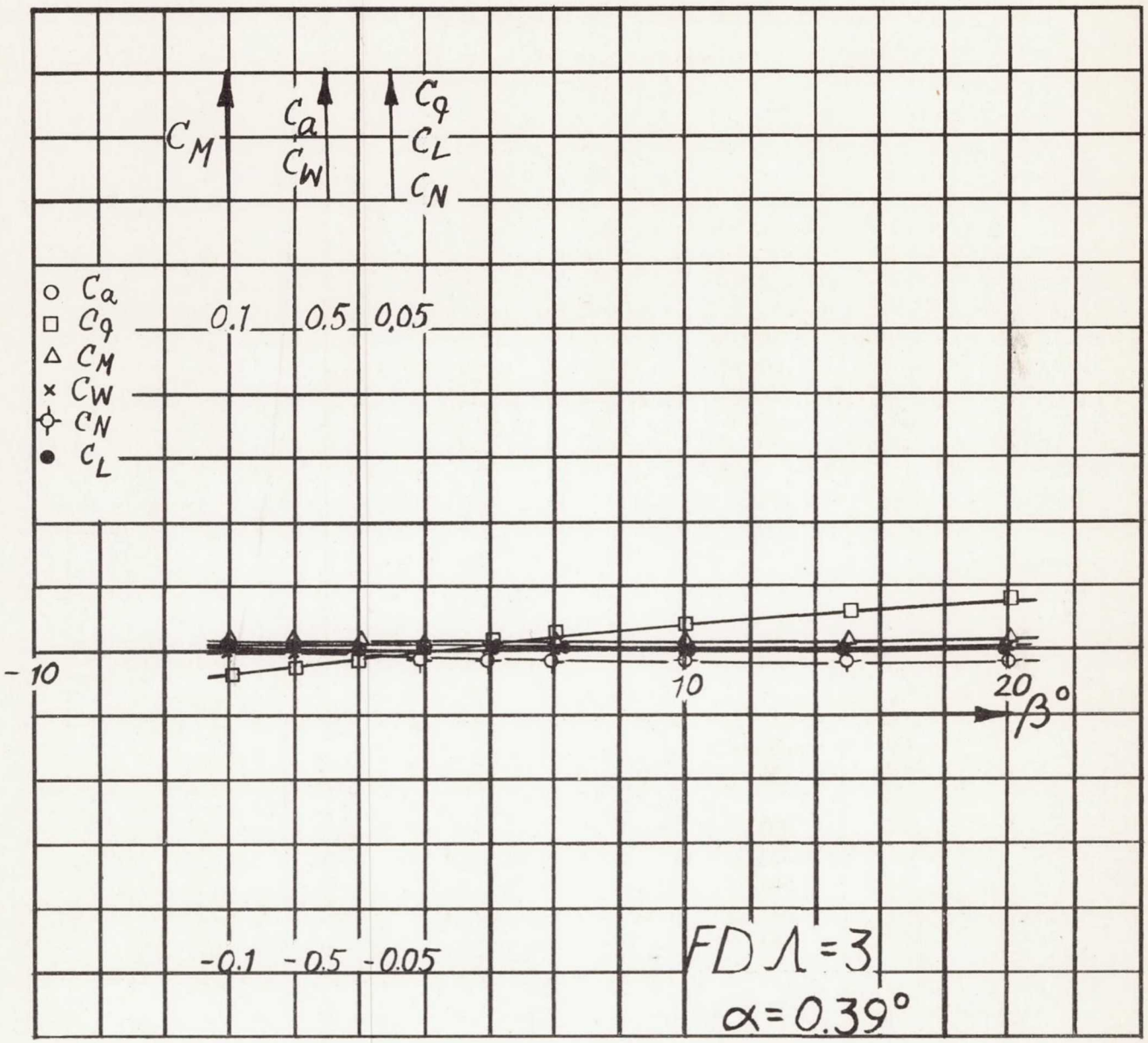

Chart 2.- 6-component measurement of a series of
Table 2.- tapered wings - triangular wings.

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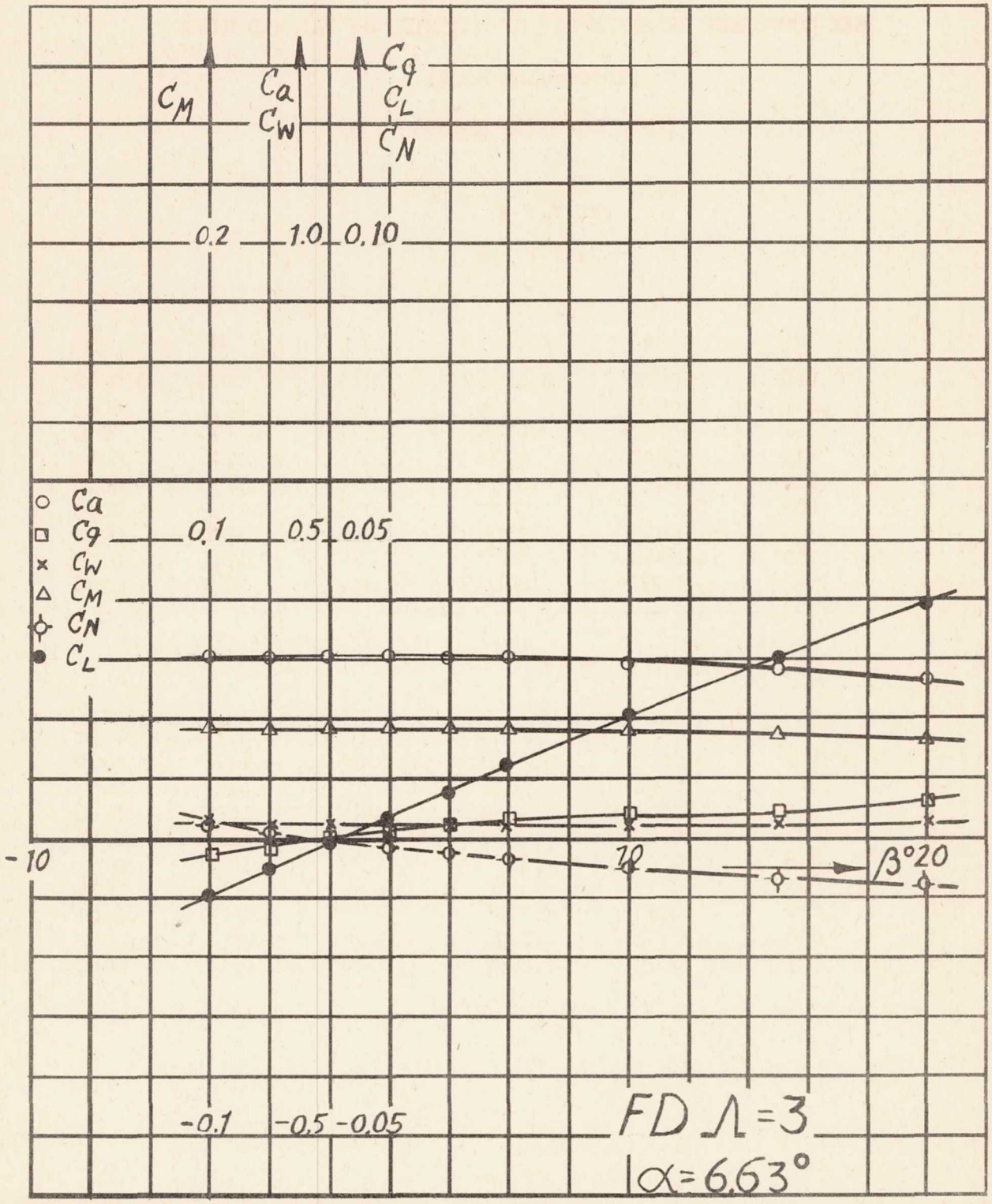

Chart 3.- 6-component measurement of a series of
Table 2.- tapered wings - triangular wings.

SIX-COMPONENT MEASUREMENTS OF A SERIES OF TAPERED WINGS

(Triangular Wing)

TABLE NO. 3 TO CHARTS 4, 5

FD $\Lambda = 3$

$\alpha = 13.56^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
-4	0.606	0.0020	0.0716	-0.0156	0.0794	0.0042
-2	.611	.0020	.0723	-.0100	.0797	.0013
0	.611	.0020	.0734	-.0037	.0796	-.0016
2	.611	.0020	.0739	.0031	.0796	-.0043
4	.610	.0013	.0737	.0093	.0795	-.0068
6	.603	0	.0727	.0161	.0793	-.0095
10	.590	-.0013	.0706	.0280	.0778	-.0150
15	.560	-.0040	.0687	.0443	.0743	-.0198
20	.532	-.0067	.0760	.0598	.0687	-.0236

$\alpha = 23.91^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
-4	0.897	0.0020	0.3290	0.0062	0.1118	-0.0012
-2	.899	.0020	.3331	0	.1117	.0006
0	.903	.0013	.3361	-.0031	.1116	.0016
2	.901	.0013	.3347	-.0087	.1112	.0043
4	.896	.0013	.3324	-.0125	.1082	.0063
6	.891	.0013	.3280	-.0169	.1074	.0074
10	.879	.0073	.3126	-.0226	.0982	.0060
15	.836	.0133	.2873	-.0264	.0851	-.0042
20	.765	.0113	.2637	-.0096	.0767	-.0081

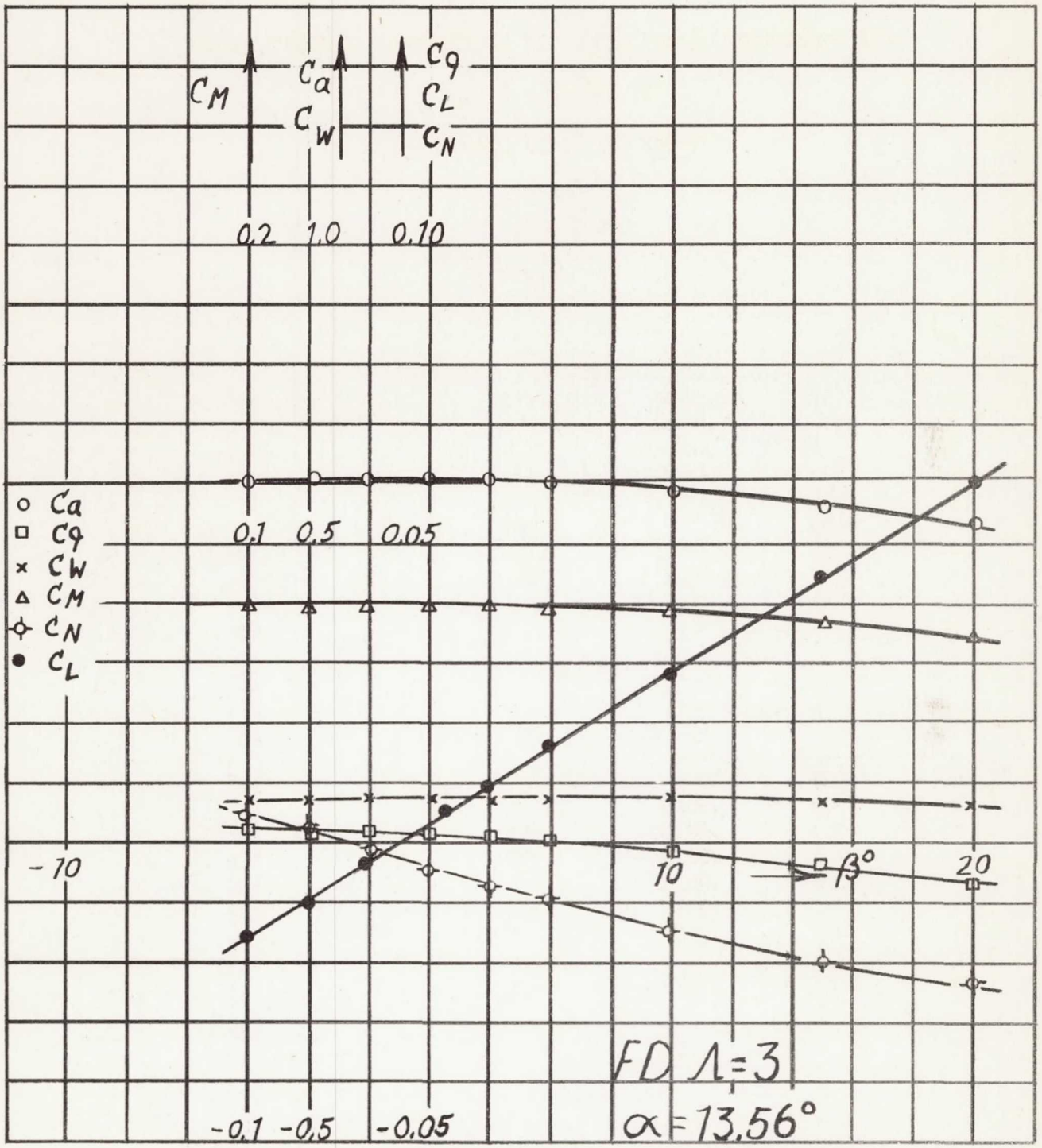

Chart 4.- 6-component measurement of a series of
Table 3.- tapered wings - triangular wings.

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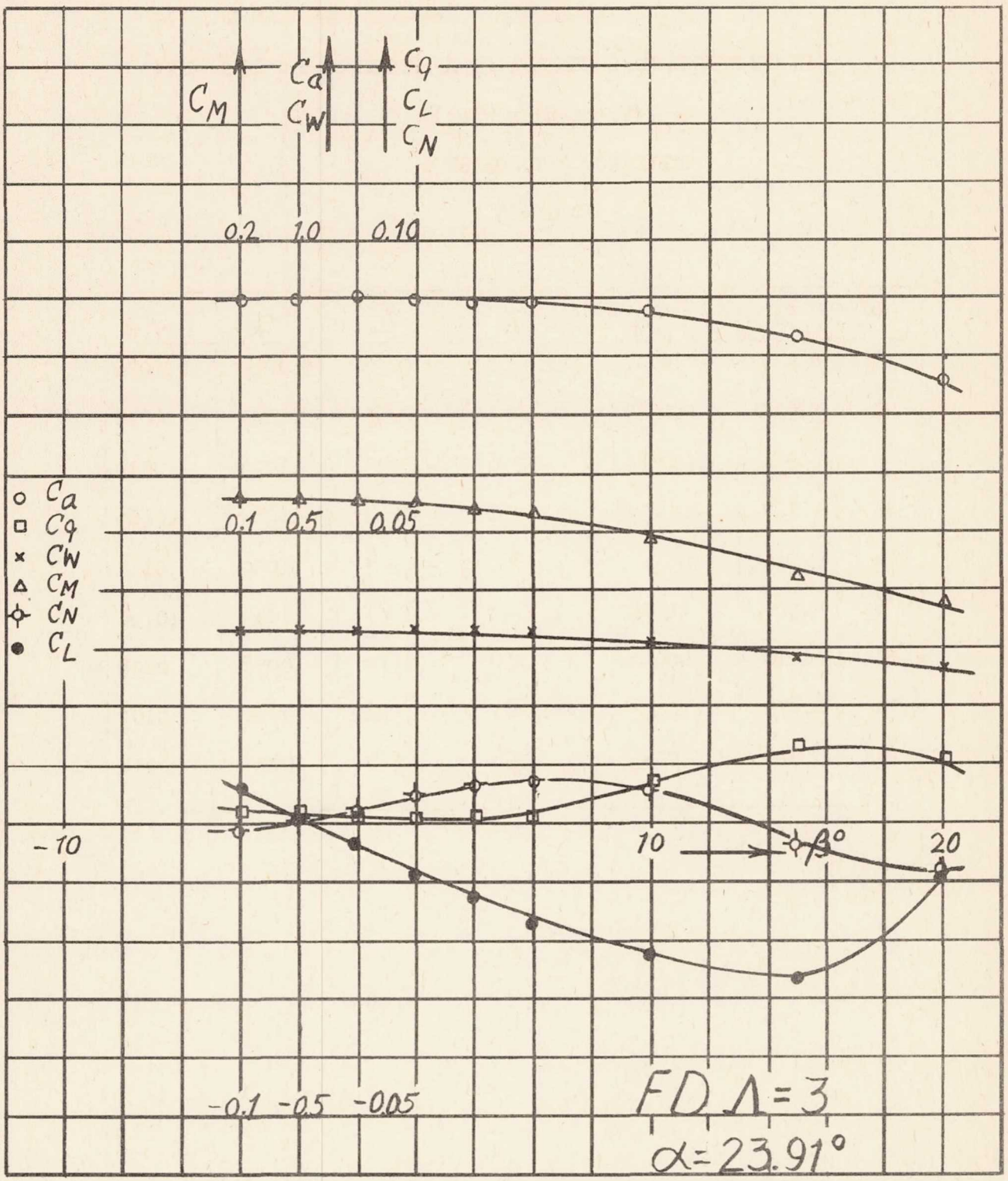

Chart 5.- 6-component measurement of a series of
Table 3.- tapered.wings - triangular wings.

SIX-COMPONENT MEASUREMENTS OF A SERIES OF TAPERED WINGS

(Triangular Wing)

TABLE NO. 4 TO CHART 6

FD $\Lambda = 3$
$\alpha = 25.89^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
-4	0.917	-0.0007	0.3886	0.0093	0.1089	-0.0074
-2	.915	-.0013	.3925	.0031	.1091	-.0035
0	.916	-.0013	.3936	-.0025	.1094	.0019
2	.917	0	.3921	-.0112	.1087	.0065
4	.919	0	.3865	-.0137	.1059	.0117
6	.910	.0020	.3833	-.0194	.1043	.0156
10	.910	.0047	.3708	-.0313	.0958	.0198
15	.870	.0153	.3401	-.0376	.0766	.0103
20	.796	-.0033	.3160	-.0238	.0715	.0014

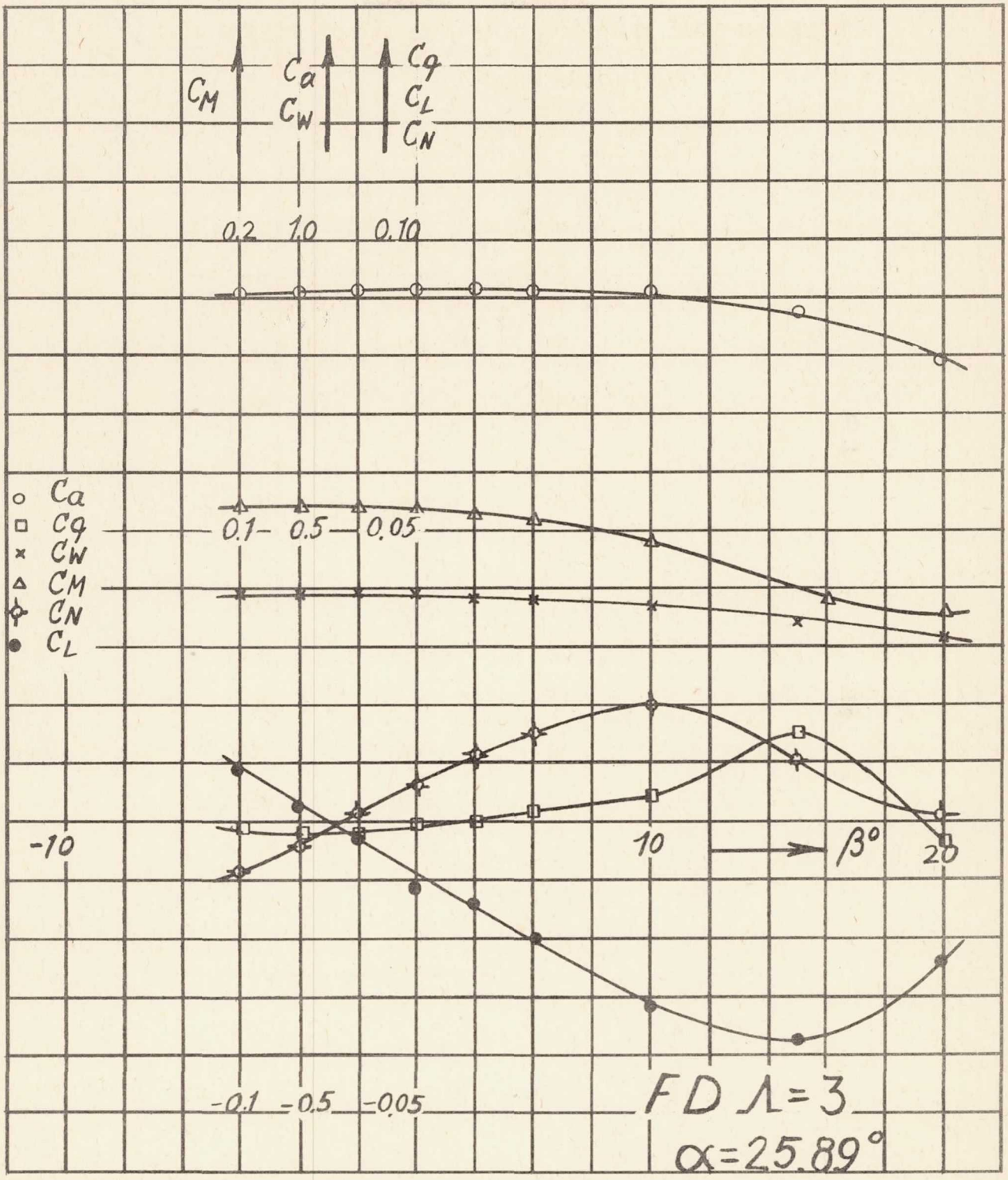

Chart 6.- 6-component measurement of a series of
Table 4.- tapered wings - triangular wings.

THREE-COMPONENT MEASUREMENTS OF A SERIES OF TAPERED WING

(Triangular Wing)

TABLE NO. 5 TO CHART 7

ED $\Lambda = 2$

α°	c_a	c_w	c_M
-5.71	-0.2375	0.0189	-0.0177
0	-.0180	.0067	-.0007
5.76	.1961	.0141	.0180
11.50	.4062	.0423	.0356
17.23	.6190	.1084	.0463
22.97	.8324	.2264	.0467
28.72	1.0360	.4146	.0506
34.58	1.1500	.6105	.0527
37.56	1.1680	.7222	.0664
40.57	1.1540	.8067	.0680
43.87	.9140	.8238	.0643
0	-.0180	.0068	-.0005
41.59	1.1360		
42.67	1.0780		

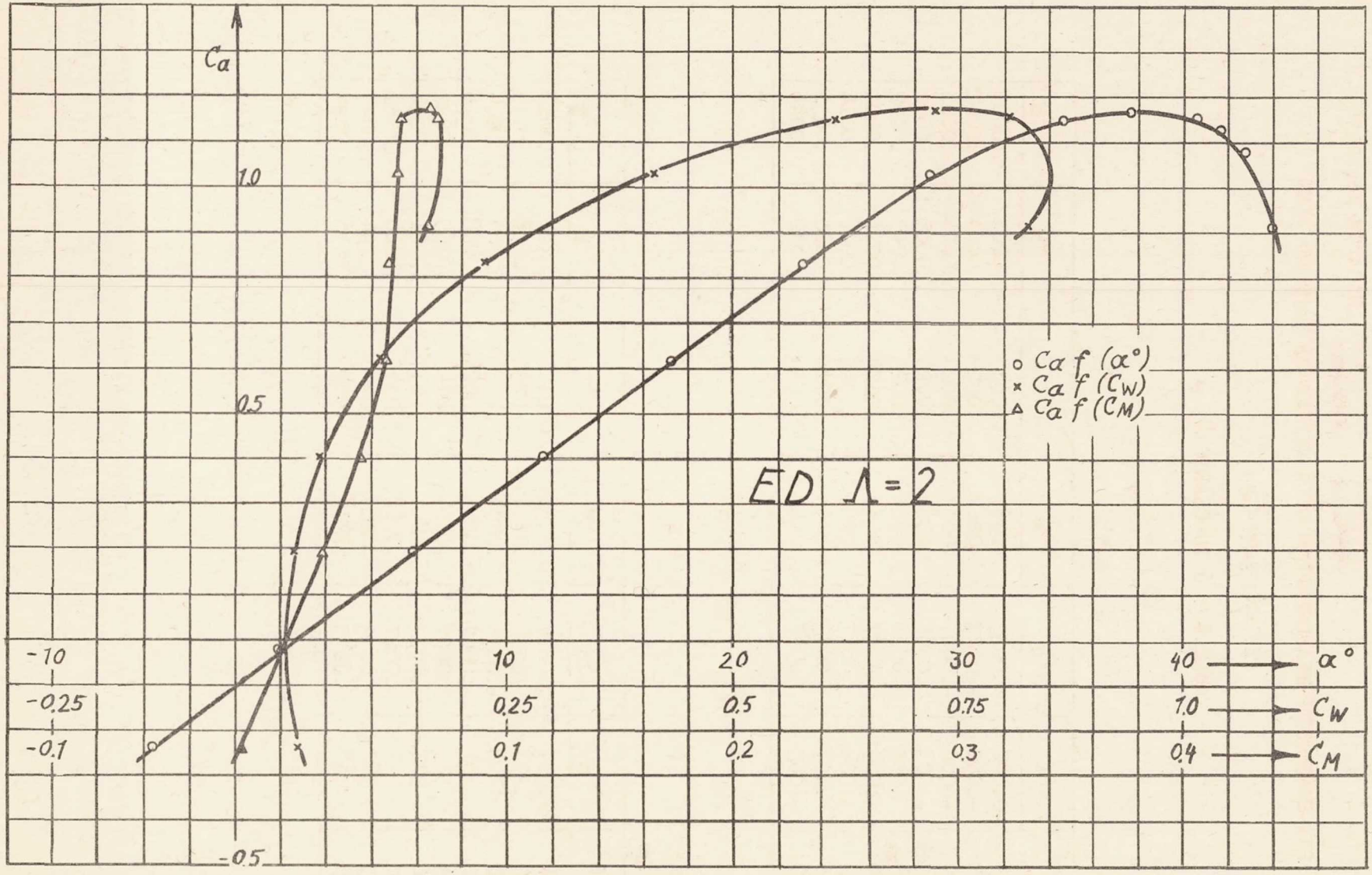

Chart 7.- 3-component measurement of a series of
Table 5.- tapered wings - triangular wings.

SIX-COMPONENT MEASUREMENTS OF A SERIES OF TAPERED WING

(Triangular Wing)

TABLE NO. 6 TO CHARTS 8, 9

ED $\Lambda = 2$

$\alpha = 0.4^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
-4	-0.002	-0.0033	0.0067	0.0023	-0.0001	-0.0001
-2	-.002	-.0027	.0063	.0023	.0004	.0007
0	-.002	-.0007	.0059	.0023	.0004	.0001
2	-.003	.0007	.0063	.0024	.0005	-.0002
4	-.002	.0020	.0067	.0024	.0004	-.0002
6	.003	.0027	.0067	.0024	.0005	.0001
10	-.004	.0047	.0087	.0025	.0008	.0014
15	-.007	.0073	.0099	.0026	.0020	.0031
20	-.005	.0087	.0112	.0015	.0012	.0044

ED $\Lambda = 2$

$\alpha = 8.63^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
-4	0.304	-0.0027	0.0256	-0.0114	0.0260	0.0018
-2	.303	-.0020	.0254	-.0052	.0268	.0015
0	.305	-.0013	.0254	.0019	.0264	-.0004
2	.303	-.0007	.0253	.0084	.0268	-.0016
4	.303	.0007	.0254	.0145	.0265	-.0032
6	.302	.0013	.0254	.0217	.0261	-.0034
10	.292	.0027	.0268	.0346	.0266	-.0051
15	.282	.0033	.0269	.0480	.0244	-.0049
20	.268	.0033	.0278	.0585	.0216	-.0034

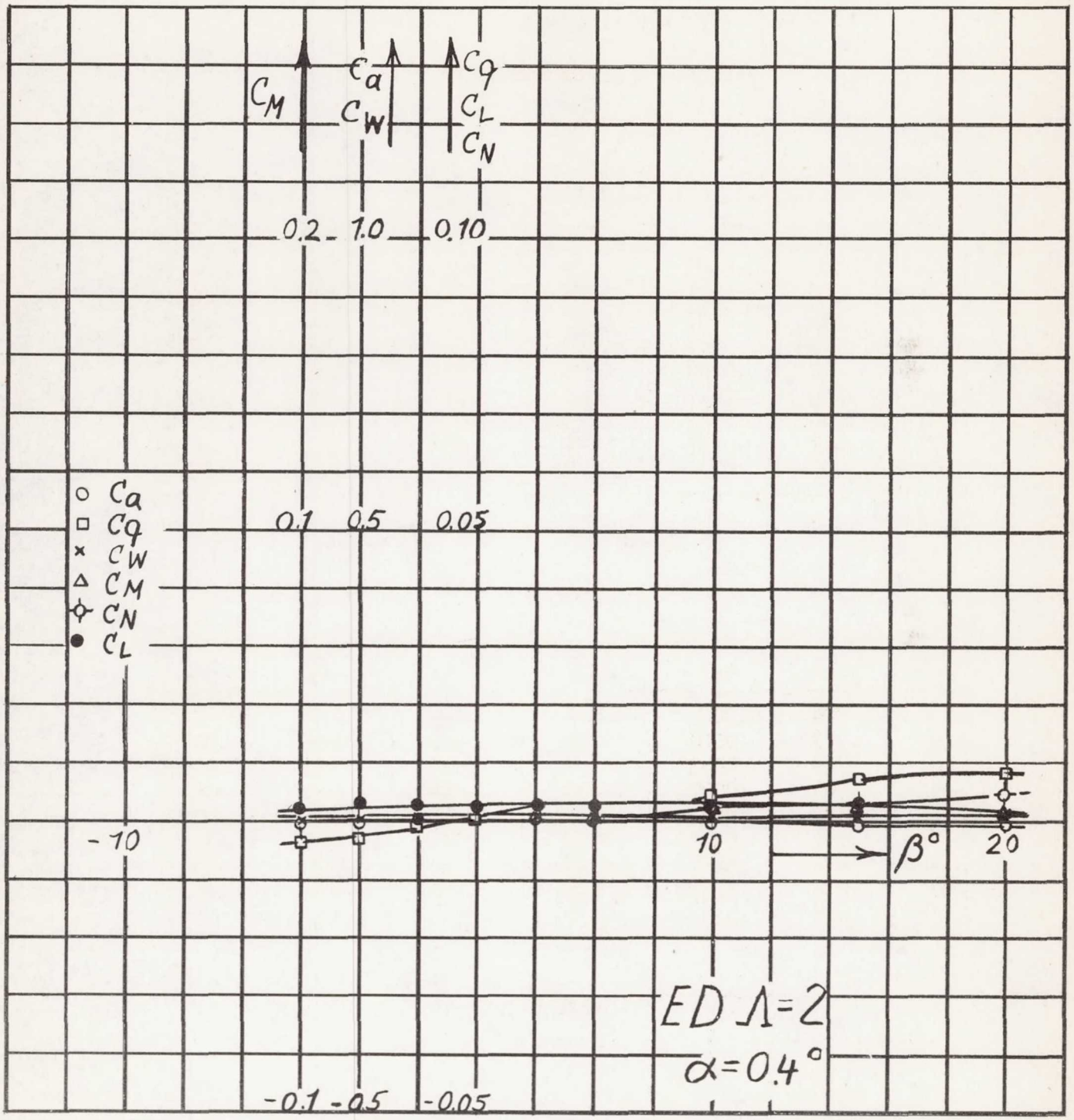

Chart 8.- 6-component measurement of a series of
Table 6.- tapered wings - triangular wings.

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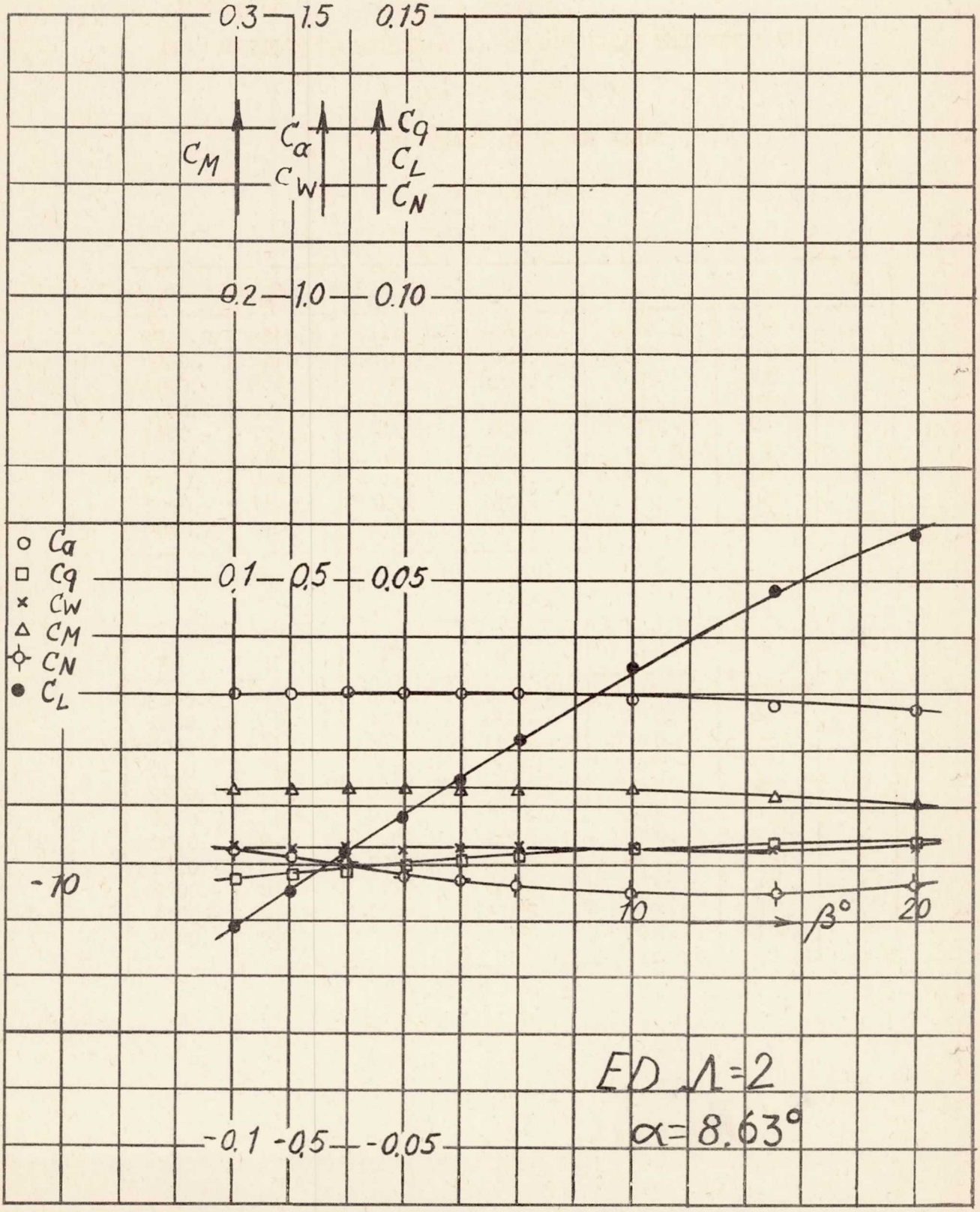

Chart 9.- 6-component measurement of a series of
Table 6.- tapered wings - triangular wings.

SIX-COMPONENT MEASUREMENTS OF A SERIES OF TAPERED WING

(Triangular Wing)

TABLE NO. 7 TO CHART 10, 11

ED $\Lambda = 2$

$\alpha = 16.86^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
-4	0.601	-0.0060	0.1021	-0.0177	0.0469	0.0122
-2	.605	-.0053	.1029	-.0087	.0462	.0068
0	.606	-.0033	.1020	.0009	.0468	.0013
2	.607	-.0040	.1011	.0099	.0461	-.0030
4	.604	-.0053	.0982	.0189	.0457	-.0067
6	.599	0	.1032	.0261	.0443	-.0137
10	.585	-.0027	.1046	.0397	.0444	-.0179
15	.561	-.0093	.1051	.0601	.0437	-.0205
20	.534	-.0193	.1006	.0800	.0422	-.0209

$\alpha = 24.96^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
0	0.907	-0.0020	0.2850	-0.0037	0.0469	0.0023
-4	.896	-.0187	.2850	-.0062	.0467	.0151
-2	.898	-.0167	.2823	-.0046	.0468	.0108
0	.907	-.0027	.2860	-.0028	.0468	.0019
2	.902	.0107	.2830	-.0020	.0459	-.0072
4	.898	.0167	.2870	-.0006	.0451	-.0116
6	.892	.0207	.2890	-.0007	.0442	-.0152
10	.860	.0147	.2913	.0107	.0451	-.0191
15	.804	.0033	.2826	.0259	.0432	-.0216
20	.742	-.0147	.2807	.0430	.0412	-.0234
0	.907	-.0027	.2853	-.0028	.0469	.0015

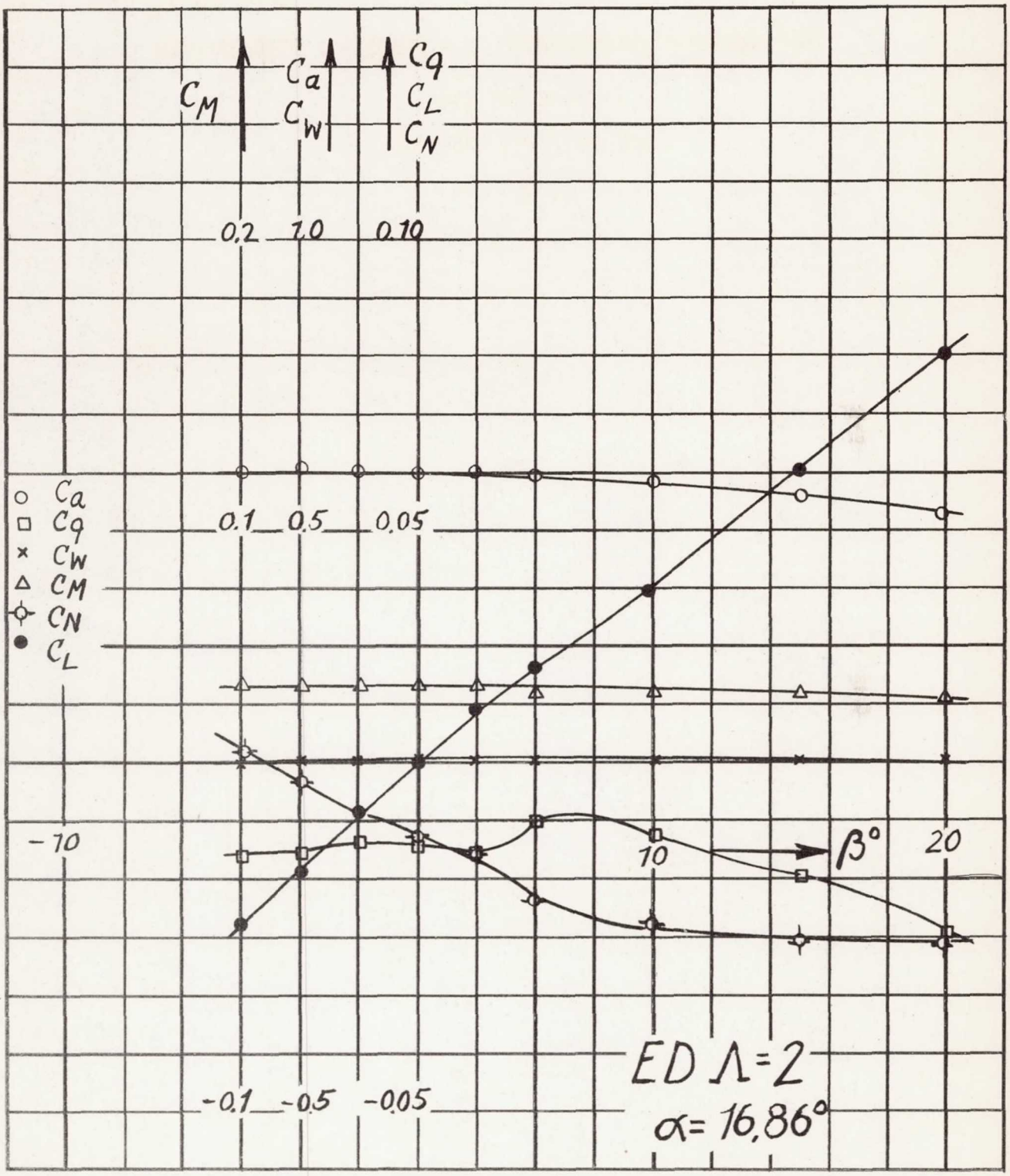

Chart 10.- 6-component measurement of a series of
Table 7.- tapered wings - triangular wings.

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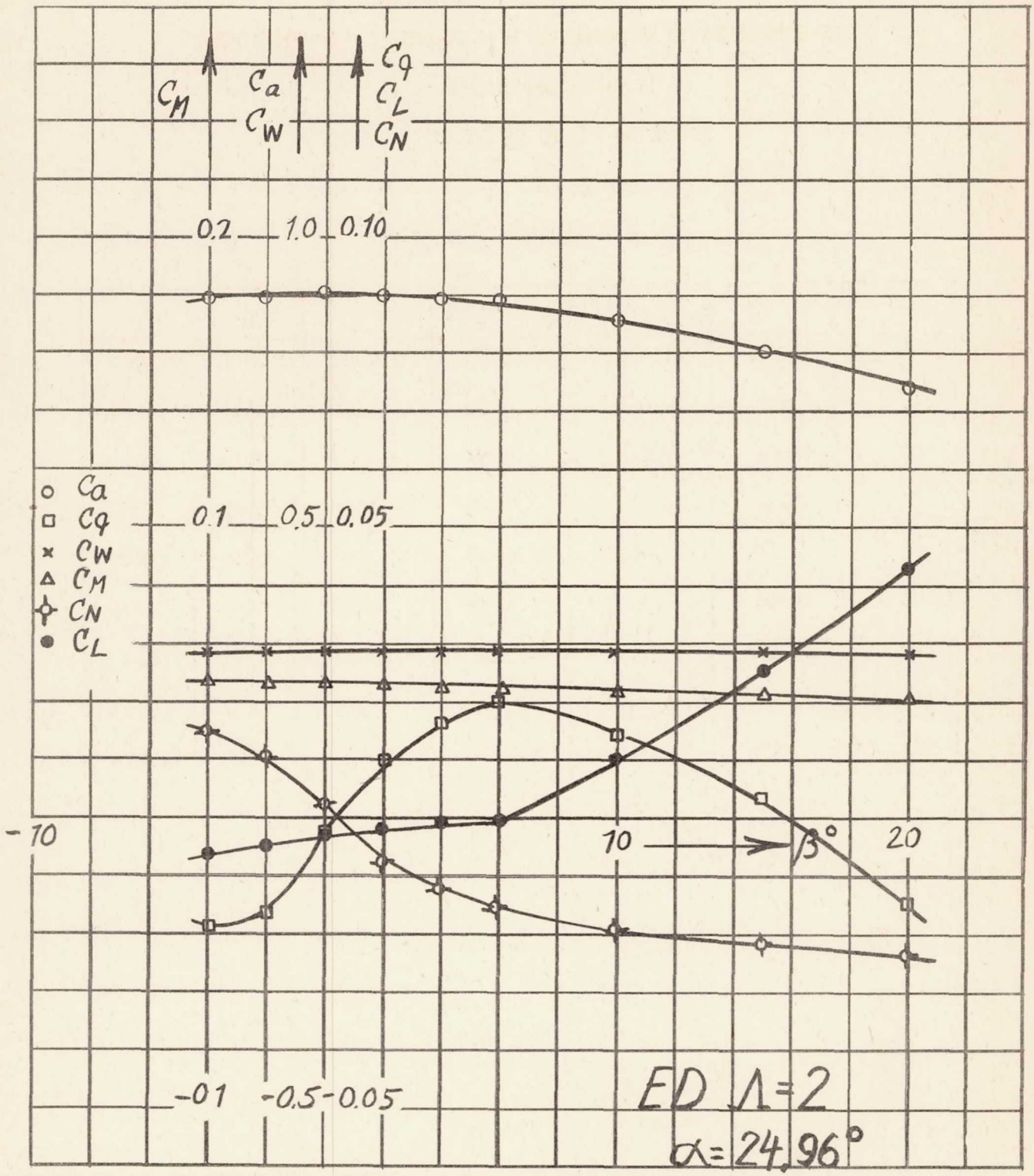

Chart 11.- 6-component measurement of a series of
Table 7.- tapered wings - triangular wings.

SIX-COMPONENT MEASUREMENTS OF A SERIES OF TAPERED WING

(Triangular Wing)

TABLE NO. 8 TO CHART 12

ED $\Lambda = 2$

$\alpha = 35.55^{\circ}$

β°	c_a	c_q	c_w	c_L	c_M	c_N
-4	1.161	-0.0107	0.6483	-0.0027	0.0460	0.0010
-2	1.159	-.0200	.6251	-.0106	.0414	.0087
0	1.156	-.0133	.6459	-.0059	.0511	.0059
2	1.192	0	.6648	-.0002	.0442	.0052
4	1.180	.0020	.6698	.0048	.0549	.0082
6	1.161	.0027	.6618	.0038	.0549	.0115
10	1.121	-.0060	.6438	.0051	.0541	.0133
15	1.058	-.0140	.6084	.0198	.0437	.0105
20	.985	-.0427	.5791	.0415	.0423	.0074

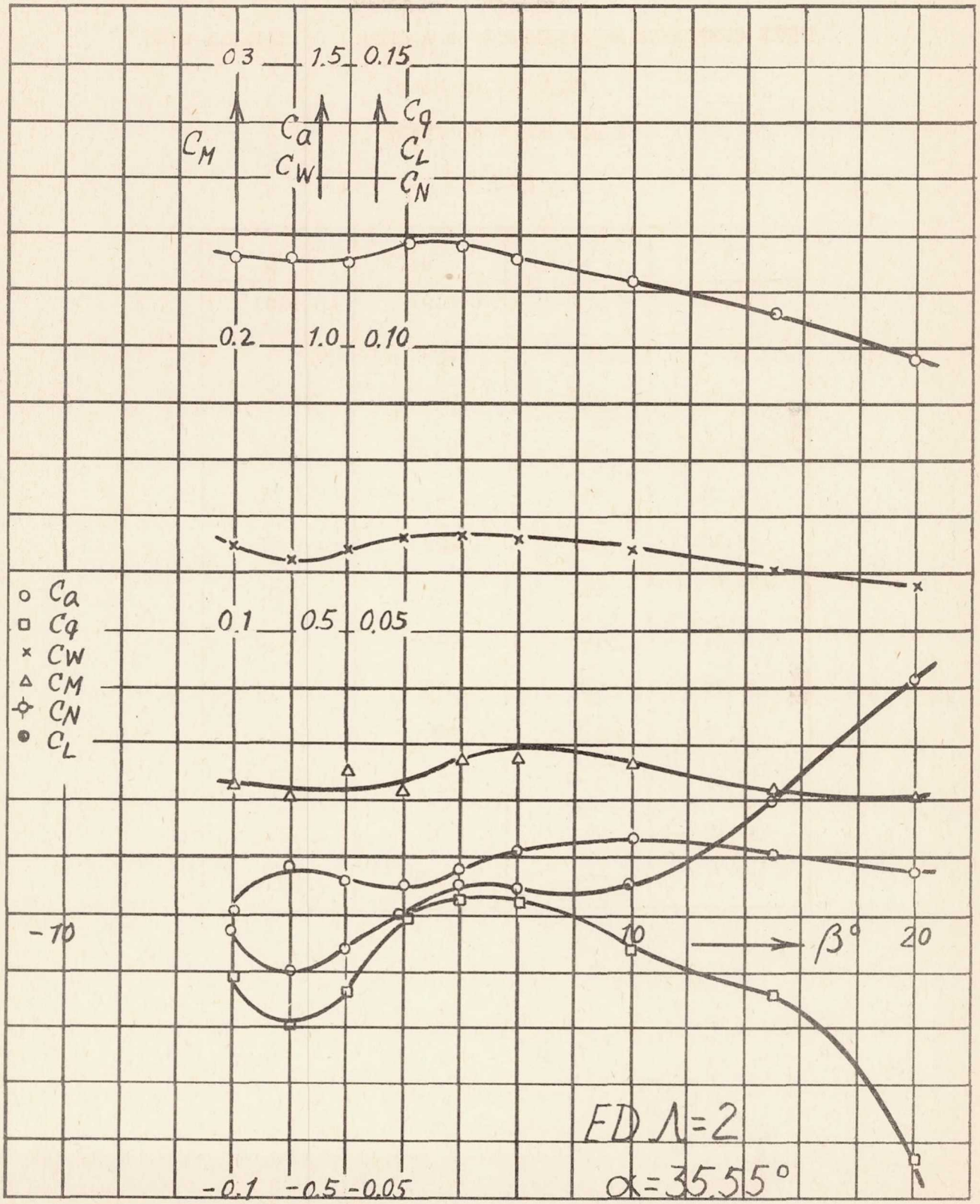

Chart 12.- 6-component measurement of a series of
Table 8.- tapered wings - triangular wings.

THREE-COMPONENT MEASUREMENTS OF A SERIES OF TAPERED WING

(Triangular Wing)

TABLE NO. 9 TO CHART 13

DD $\Lambda = \frac{4}{3}$

α^o	c_a	c_w	c_M
-5.81	-0.152	0.0121	-0.0101
0	.002	.0052	0
5.80	.156	.0135	.0089
11.59	.325	.0398	.0150
17.35	.513	.1030	.0046
23.10	.711	.2243	-.0152
28.89	.884	.3699	-.0208
31.81	.945	.4480	-.0169
34.76	.984	.5350	-.0239
37.72	1.015	.6253	-.0257
38.70	1.035	.6611	-.0241
39.70	1.033	.6862	-.0200
40.71	1.025	.7108	-.0140

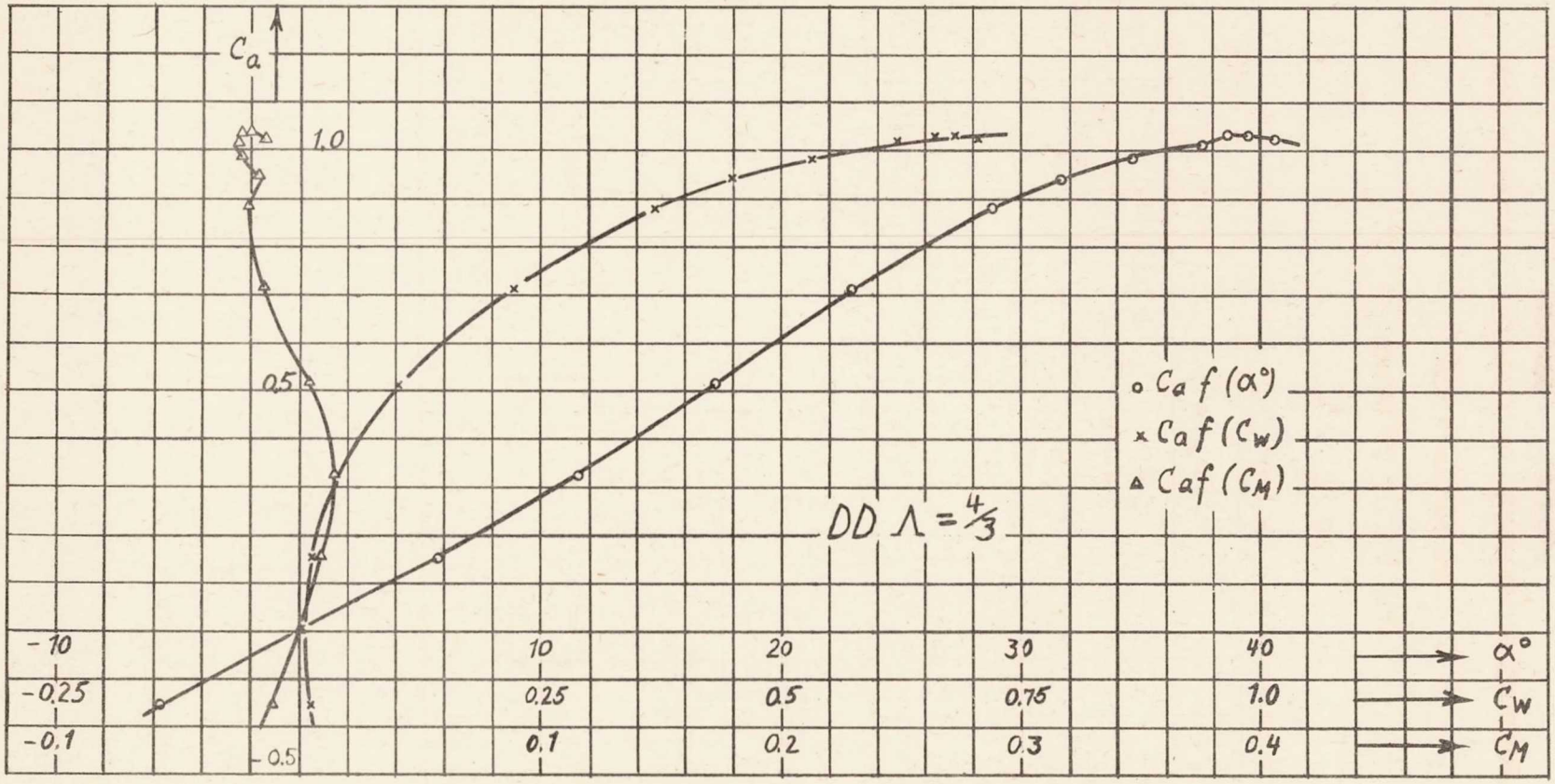

Chart 13.- 3-component measurement of a series of
Table 9.- tapered wings - triangular wings.

SIX-COMPONENT MEASUREMENTS OF A SERIES OF TAPERED WING

(Triangular Wing)

TABLE NO. 10 TO CHARTS 14, 15

DD $\Lambda = \frac{4}{3}$

$\alpha = 0^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
-4	0.0063	-0.0013	0.0049	-0.0001	0.0014	-0.0045
-2	.0068	-.0010	.0043	0	.0019	-.0025
0	.0045	0	.0043	0	.0011	-.0003
2	.0037	.0013	.0046	.0009	.0011	0
4	.0052	.0013	.0048	.0001	.0014	.0043
6	.0044	.0023	.0055	.0067	.0013	.0066
10	.0052	.0040	.0059	.0067	.0019	.0118
15	.0056	.0078	.0081	.0069	.0022	.0197
20	.0055	.0150	.0119	.0061	.0016	.0309

$\alpha = 10.63^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
-4	0.3019	0.0007	0.0343	-0.0167	0.0131	-0.0020
-2	.2969	-.0010	.0324	-.0089	.0149	-.0011
0	.2969	-.0020	.0334	-.0008	.0140	.0003
2	.3002	-.0020	.0339	.0090	.0138	.0021
4	.3010	-.0013	.0343	.0186	.0130	.0019
6	.2978	-.0017	.0350	.0260	.0114	.0042
10	.2970	-.0020	.0360	.0397	.0101	.0096
15	.2849	.0025	.0377	.0607	.0085	.0156
20	.2646	.0097	.0390	.0721	.0045	.0252

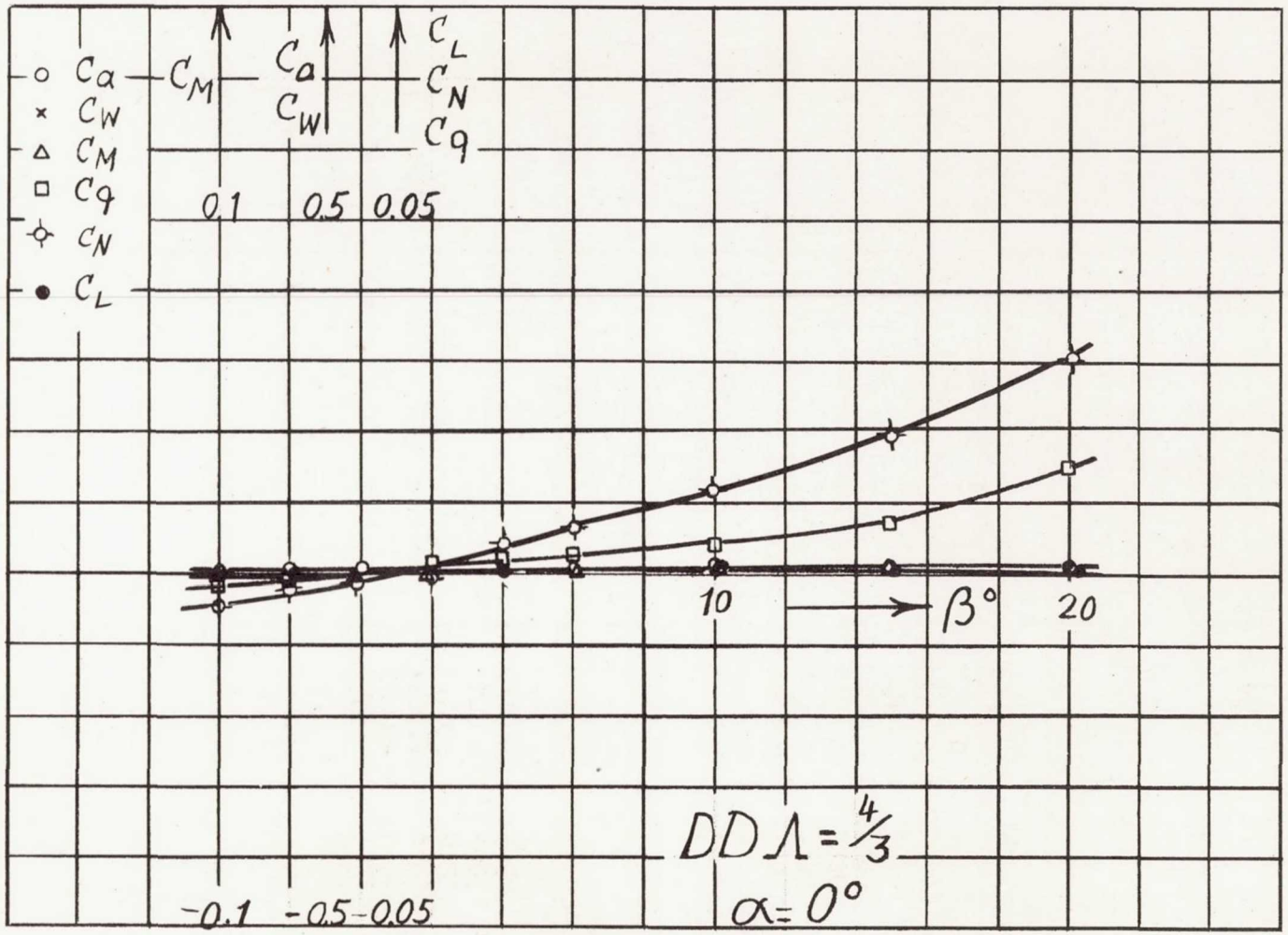

Chart 14.- 6-component measurement of a series of
Table 10.- tapered wings - triangular wings.

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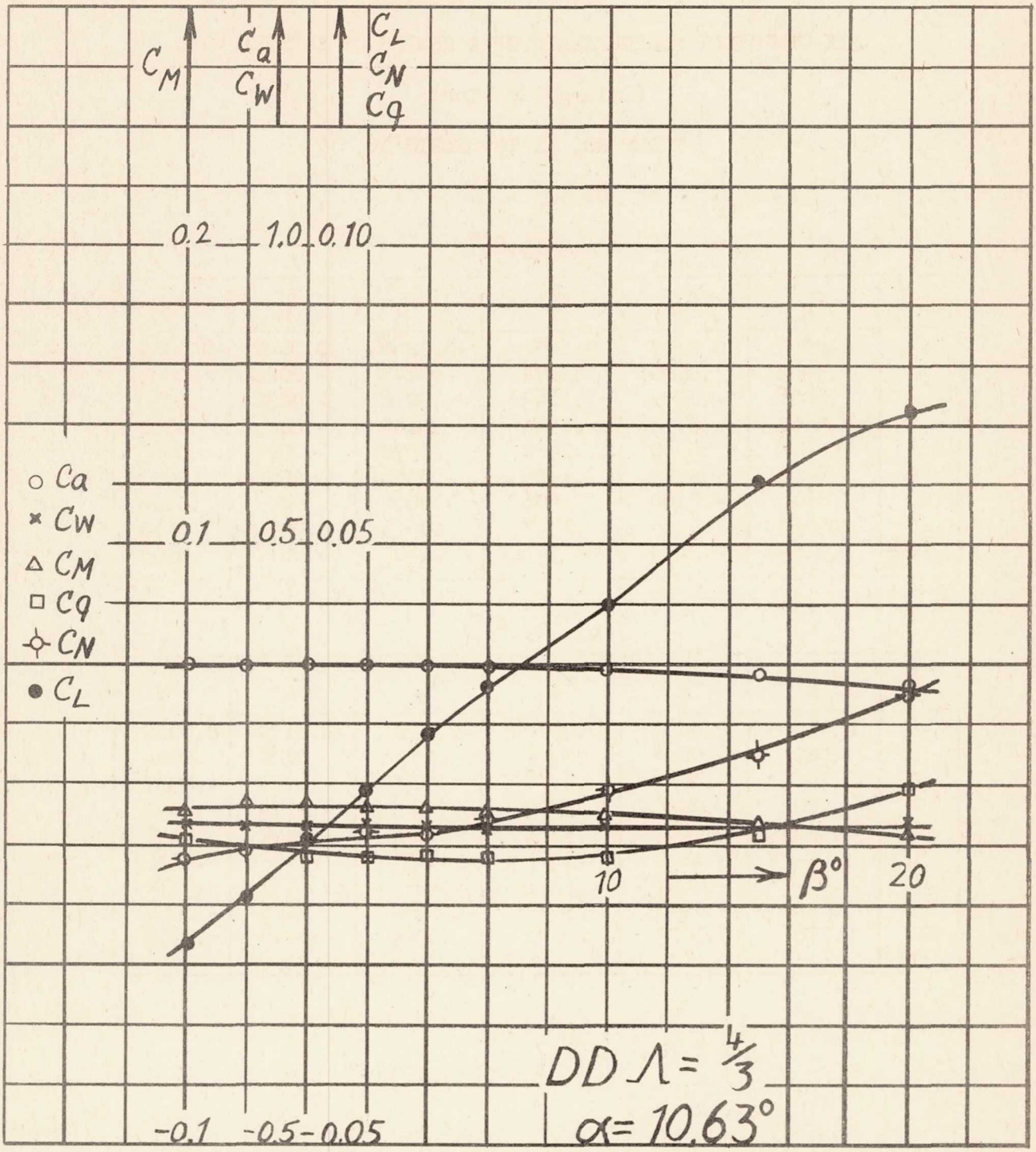

Chart 15.- 6-component measurement of a series of
Table 10.- tapered wings - triangular wings.

SIX-COMPONENT MEASUREMENTS OF A SERIES OF TAPERED WING

(Triangular Wing)

TABLE NO. 11 TO CHARTS 16, 17

DD $\Lambda = \frac{4}{3}$

$\alpha = 19.86^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
-4	0.5976	0.0107	0.1452	-0.0260	0.0002	-0.0014
-2	.5982	.0030	.1474	-.0145	-.0026	-.0005
0	.6008	-.0073	.1463	.0018	-.0020	.0050
2	.5967	-.0133	.1443	.0149	-.0003	.0060
4	.5890	-.0180	.1421	.0270	.0019	.0065
6	.5980	-.0250	.1455	.0346	-.0002	.0091
10	.5810	-.0360	.1406	.0664	.0001	.0126
15	.5535	-.0355	.1337	.0975	.0009	.0115
20	.5159	-.0243	.1331	.1167	-.0011	.0107

$\alpha = 29.89^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
-4	0.9020	0.0080	0.3908	-0.0110	-0.0189	0.0032
-2	.9003	-.0017	.3928	.0030	-.0186	.0004
0	.9080	-.0087	.3988	.0165	-.0164	-.0037
2	.9002	-.0120	.3979	.0228	-.0174	-.0091
4	.9054	-.0107	.3927	.0199	-.0152	-.0134
6	.9049	-.0137	.3883	.0178	-.0152	-.0165
10	.8870	-.0667	.3713	.0742	-.0137	-.0072
15	.8350	-.0942	.3453	.1271	-.0065	-.0090
20	.7763	-.1023	.3178	.1596	-.0048	-.0102

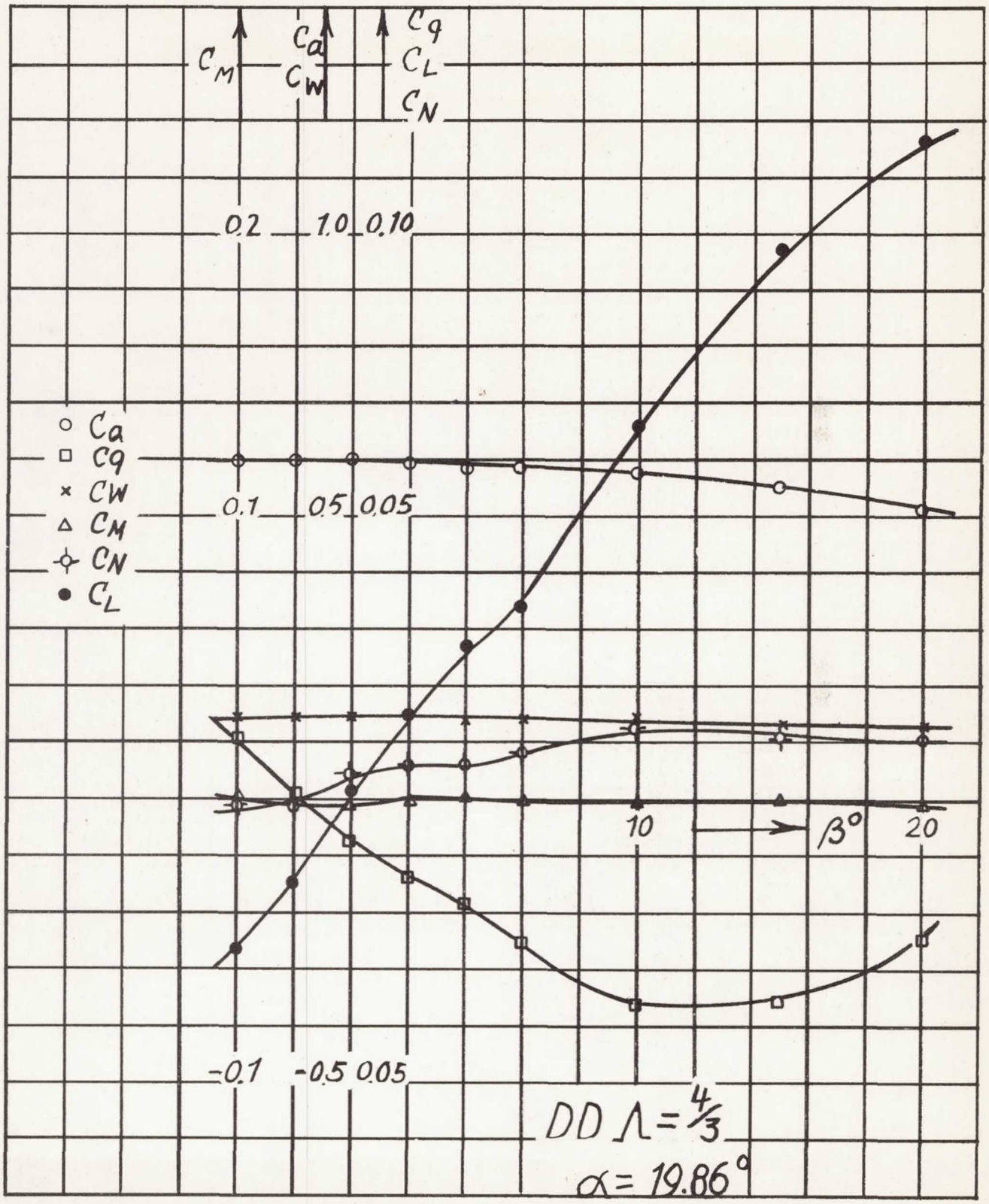

Chart 16.- 6-component measurement of a series of
Table 11.- tapered wings - triangular wings.

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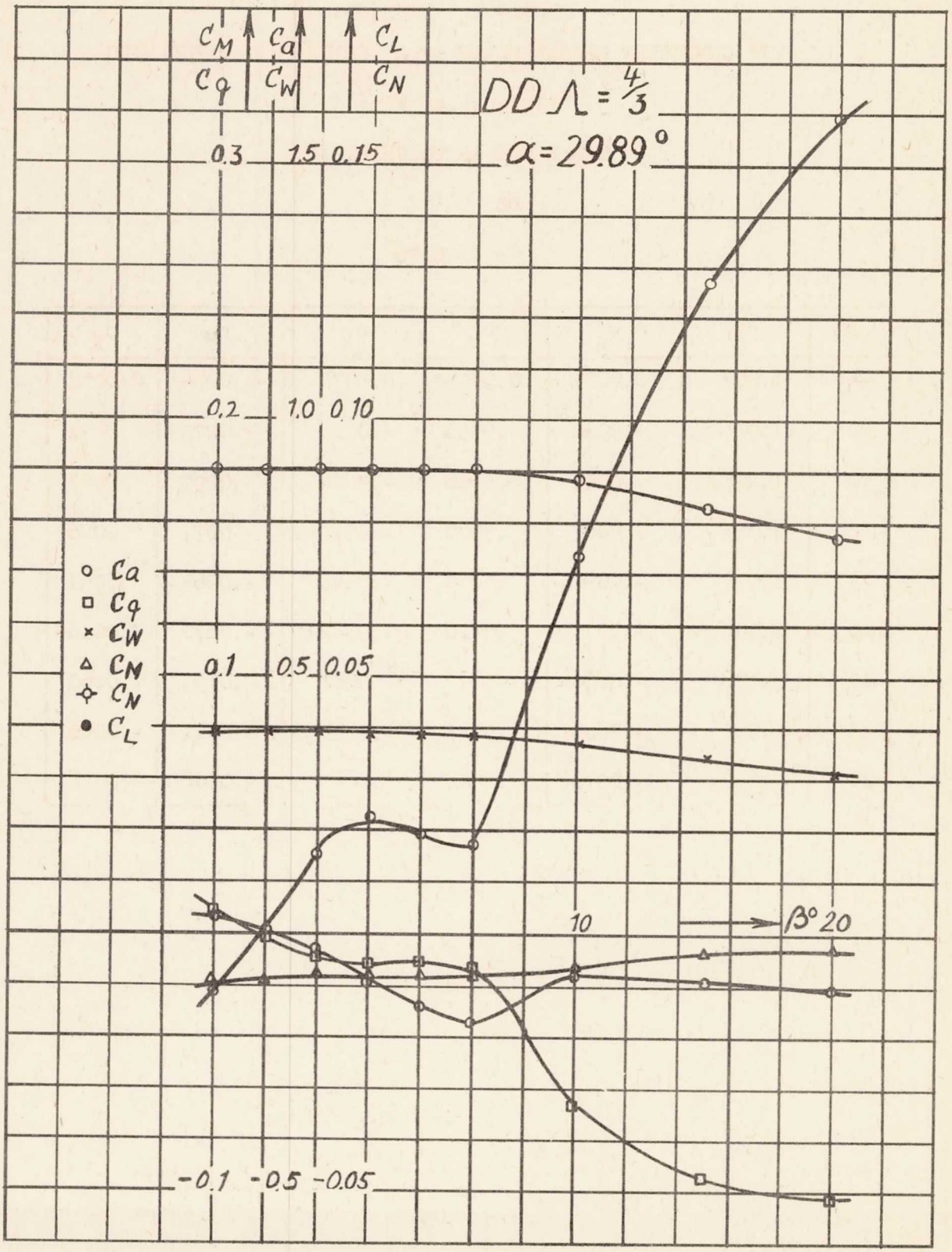

Chart 17.- 6-component measurement of a series of
Table 11.- tapered wings - triangular wings.

SIX-COMPONENT MEASUREMENTS OF A SERIES OF TAPERED WING

(Triangular Wing)

TABLE NO. 12 TO CHART 18

DD $\Lambda = \frac{4}{3}$

$\alpha = 36.76^{\circ}$

β°	c_a	c_q	c_w	c_L	c_M	c_N
-4	1.007	0.0027	0.5893	0.0034	-0.0254	0.0052
-2	1.024	.0010	.5956	-.0010	-.0273	.0031
0	1.025	-.0007	.5966	-.0054	-.0297	.0024
2	1.022	-.0007	.5920	-.0099	-.0277	.0026
4	1.006	-.0020	.5899	-.0141	-.0263	.0031
6	1.003	-.0077	.5916	-.0042	-.0272	.0016
10	.978	-.0280	.5833	.0067	-.0193	-.0060
15	.915	-.0608	.5513	.0359	-.0111	-.0066
20	.830	-.0936	.5045	.0847	-.0008	-.0058

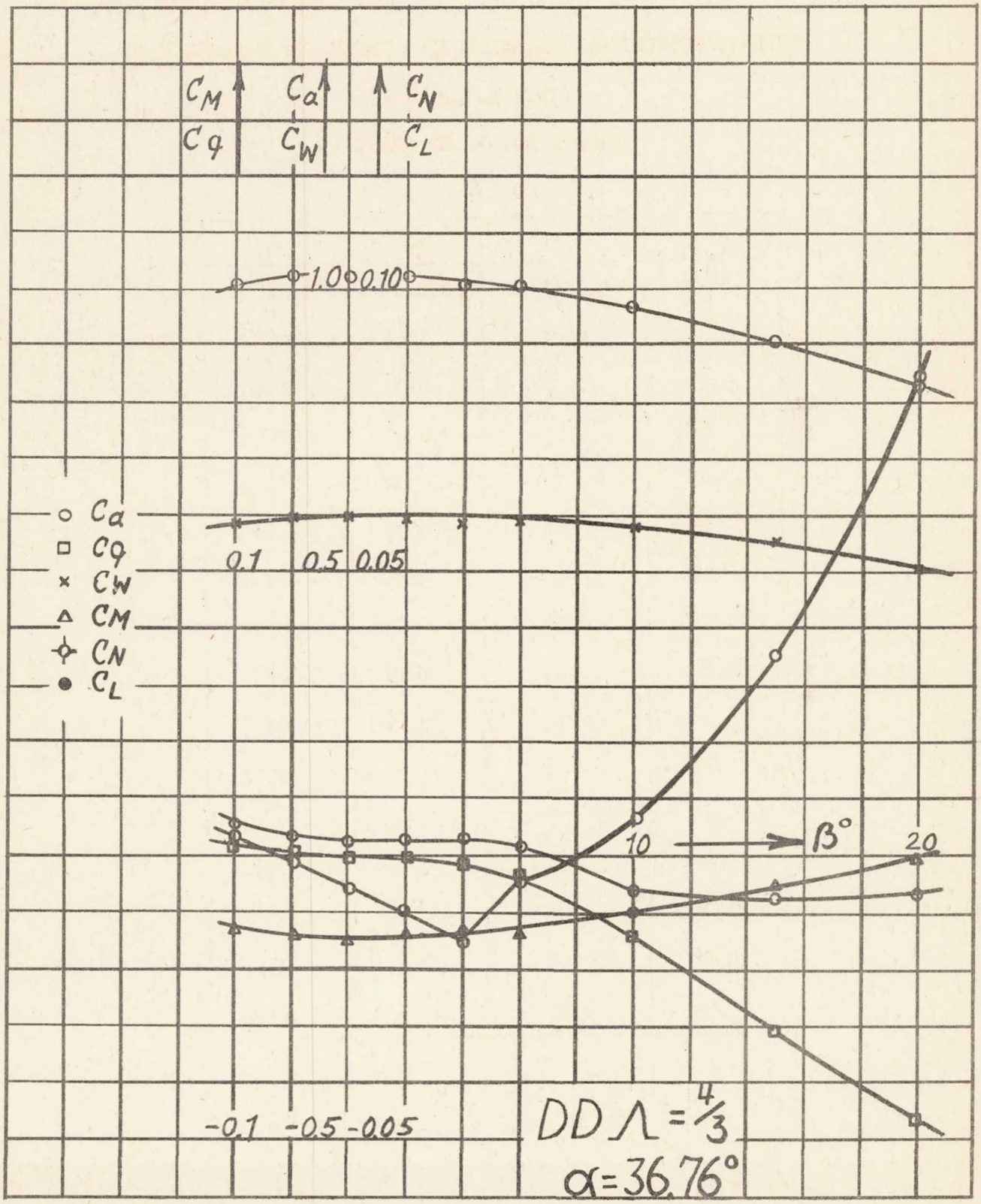

Chart 18.- 6-component measurement of a series of
Table 12.- tapered wings - triangular wings.

THREE-COMPONENT MEASUREMENTS OF A SERIES OF TAPERED WING

(Triangular Wing)

TABLE NO. 13 TO CHART 19

CD Λ = 1

α^{o}	c_a	c_w	c_M
-5.84	-0.1258	0.0114	-0.0047
0	-.0002	.0064	-.0060
5.84	.1255	.0115	.0067
11.68	.2525	.0364	.0029
17.48	.4136	.0964	-.0139
23.21	.6272	.2077	-.0443
28.96	.8230	.3635	-.0776
31.86	.9040	.4553	-.0823
32.84	.9193	.4826	-.0871
33.83	.9273	.5016	-.0798
34.83	.9288	.5195	-.0793
35.81	.9408	.5482	-.0722
36.81	.9440	.5695	-.0669
37.82	.9392	.5883	-.0627
38.81	.9418	.6110	-.0623
39.80	.9520	.6385	-.0624

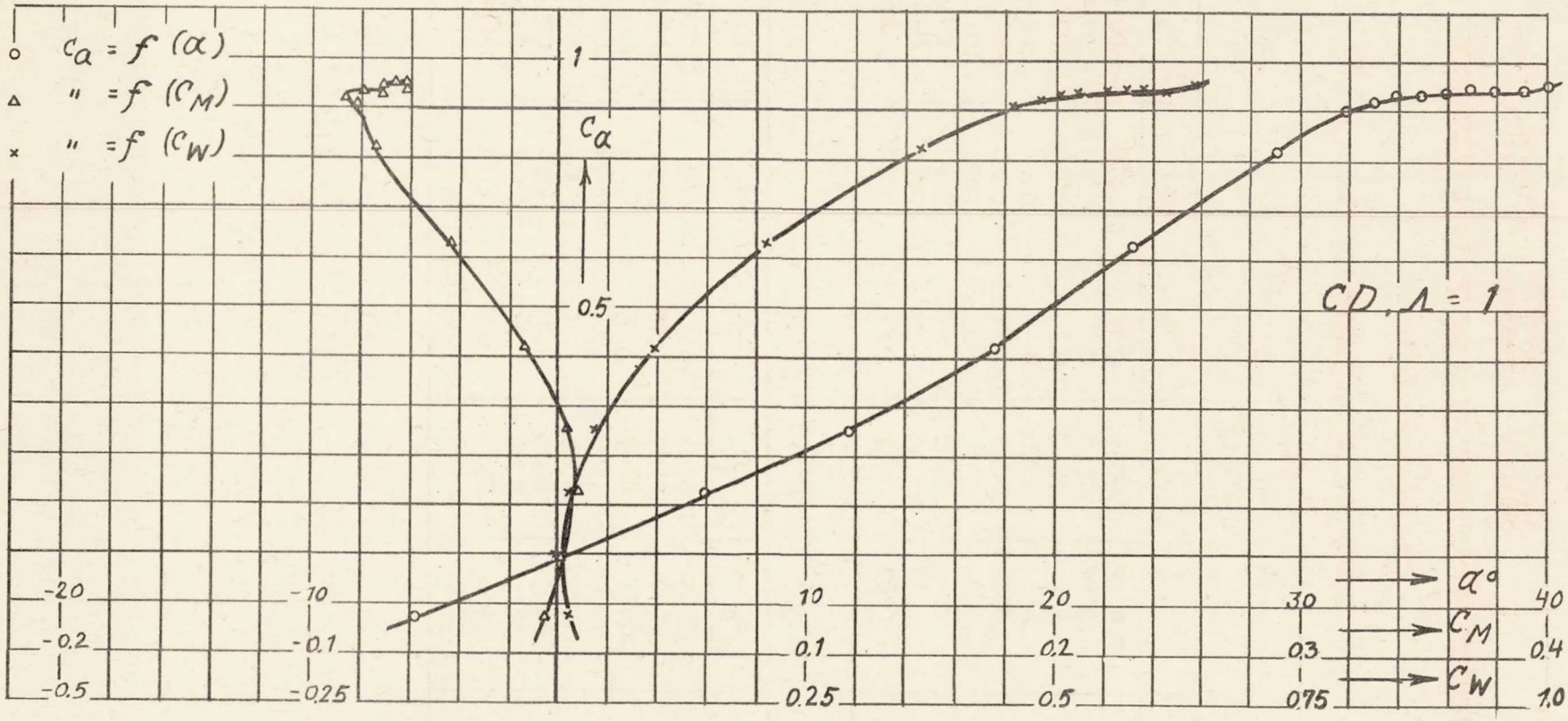

Chart 19.- 3-component measurement of a series of
Table 13.- tapered wings - triangular wings.

SIX-COMPONENT MEASUREMENTS OF A SERIES OF TAPERED WING

(Triangular Wing)

TABLE NO. 14 TO CHARTS 20, 21

CD Λ = 1

$\alpha = 0^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
-4	0.0012	-0.0012	0.0053	-0.0011	0.0016	-0.0094
-2	.0039	-.0002	.0058	0	.0020	-.0040
0	.0021	0	.0058	0	.0022	.0003
2	.0008	.0013	.0060	0	.0021	.0049
4	-.0006	.0022	.0070	-.0011	.0021	.0101
6	.0048	.0040	.0076	.0021	.0026	.0173
10	.0021	.0085	.0088	.0011	.0022	.0316
15	.0017	.0187	.0130	.0011	.0027	.0481
20	.0036	.0367	.0203	.0011	.0022	.0875

$\alpha = 13.03^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
-4	0.3064	0.0055	0.0504	-0.0182	-0.0004	-0.0168
-2	.3010	.0002	.0467	-.0062	.0017	-.0056
0	.2986	-.0027	.0467	.0012	.0026	.0013
2	.3010	-.0057	.0490	.0130	.0004	.0095
4	.3026	-.0072	.0510	.0237	.0001	.0175
6	.2987	-.0053	.0501	.0341	-.0004	.0234
10	.2906	.0015	.0506	.0539	-.0027	.0379
15	.2735	.0160	.0589	.0752	-.0077	.0644
20	.2506	.0280	.0440	.1047	-.0143	.0894

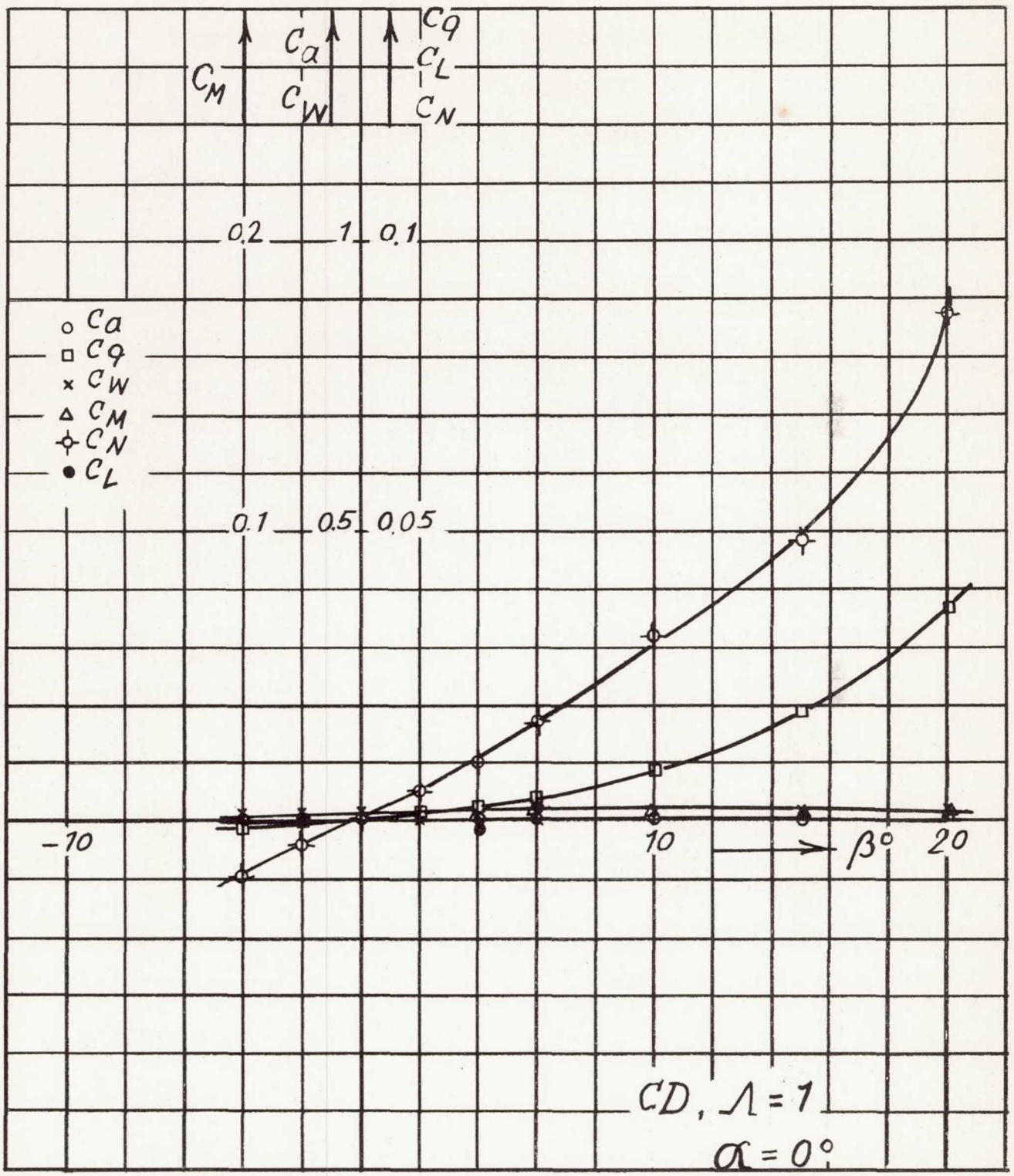

Chart 20.- 6-component measurement of a series of
Table 14.- tapered wings - triangular wings.

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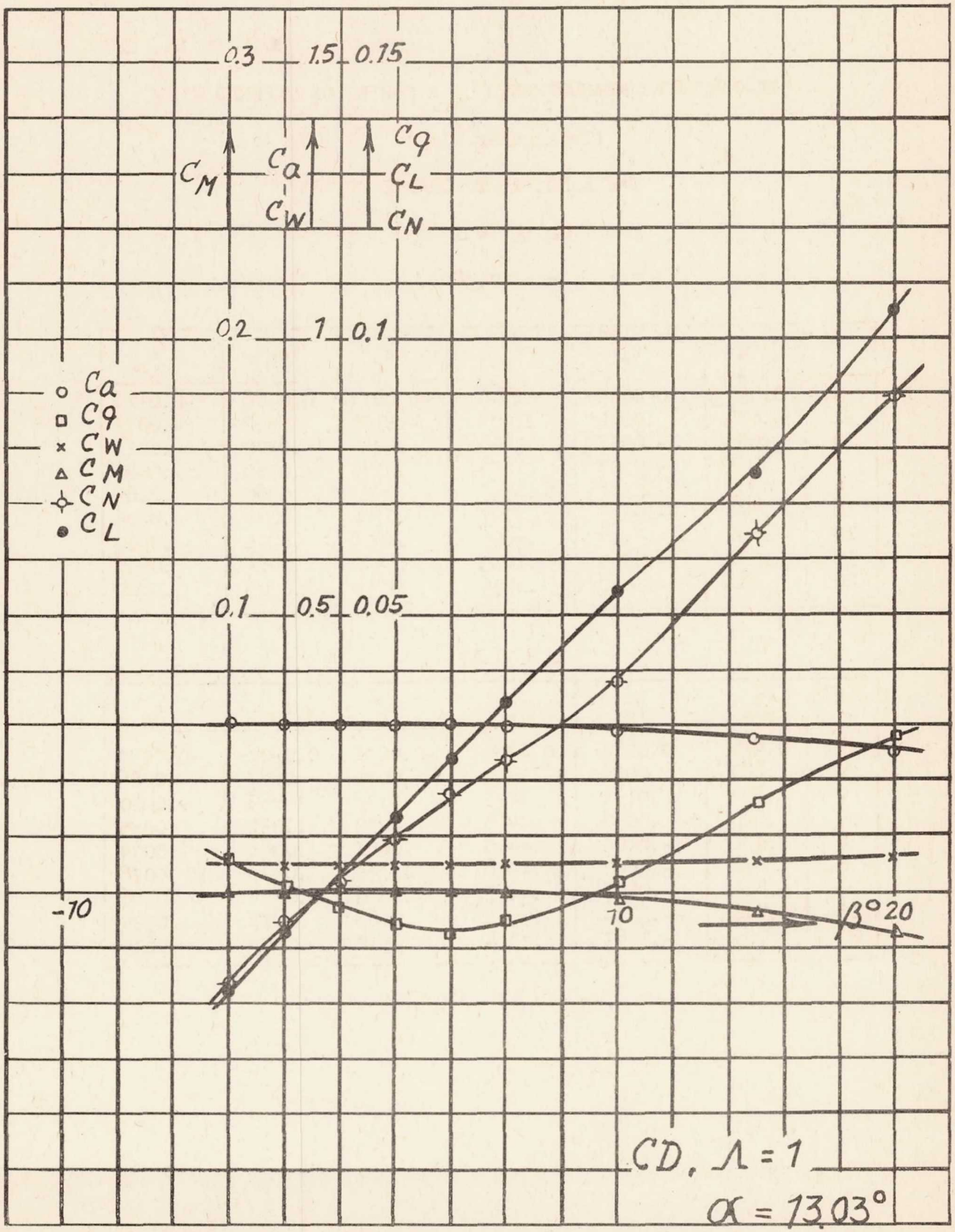

Chart 21.- 6-component measurement of a series of
Table 14.- tapered wings - triangular wings.

SIX-COMPONENT MEASUREMENTS OF A SERIES OF TAPERED WING

(Triangular Wing)

TABLE NO. 15 TO CHARTS 22, 23

CD Λ = 1

$\alpha = 22.38^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
-4	0.592	0.0042	0.1846	-0.0215	0.0368	-0.0118
-2	.604	.0042	.1903	-.0104	.0397	-.0073
0	.595	-.0027	.1865	.0056	.0370	-.0011
2	.591	-.0037	.1854	.0179	.0369	.0042
4	.589	-.0398	.1867	.0505	.0300	.0162
6	.578	-.0393	.1797	.0701	.0278	.0304
10	.556	-.0352	.1699	.1008	.0275	.0460
15	.521	-.0300	.1615	.1440	.0284	.0655
20	.481	-.0340	.1559	.1750	.0305	.0829

$\alpha = 31.67^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
-4	0.876	0.0082	0.4385	-0.0291	0.0907	-0.0053
-2	.880	.0055	.4399	-.0072	.0887	-.0064
0	.890	-.0073	.4436	.0138	.0935	-.0020
2	.895	.0050	.4485	.0242	.1031	.0055
4	.891	-.0405	.4455	.0652	.0981	.0034
6	.876	-.0660	.4368	.1050	.0927	.0078
10	.811	-.0898	.3925	.1536	.0674	.0346
15	.746	-.1234	.3511	.2168	.0572	.0524
20	.706	-.1387	.3314	.2512	.0570	.0619

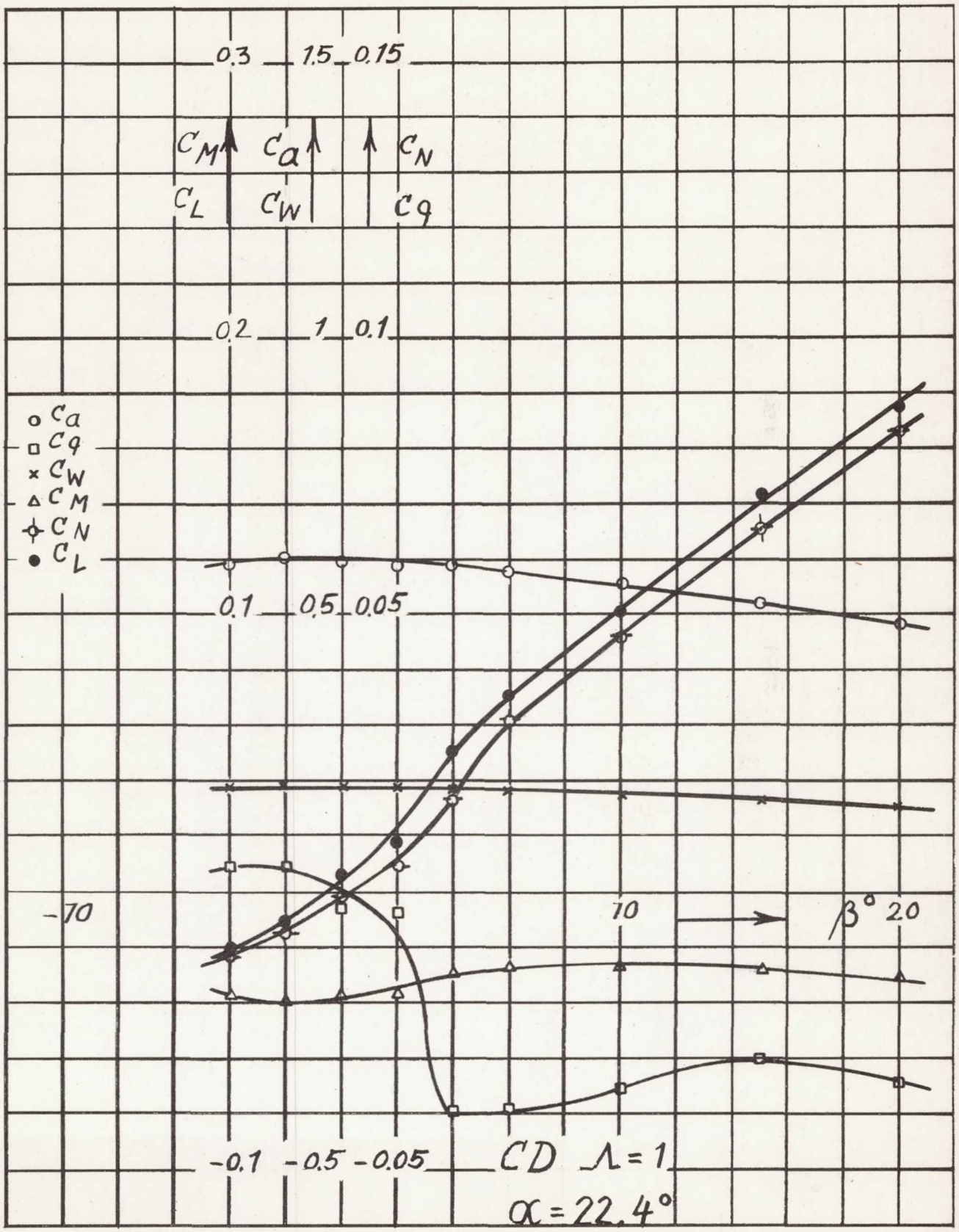

Chart 22.- 6-component measurement of a series of
Table 15.- tapered wings - triangular wings.

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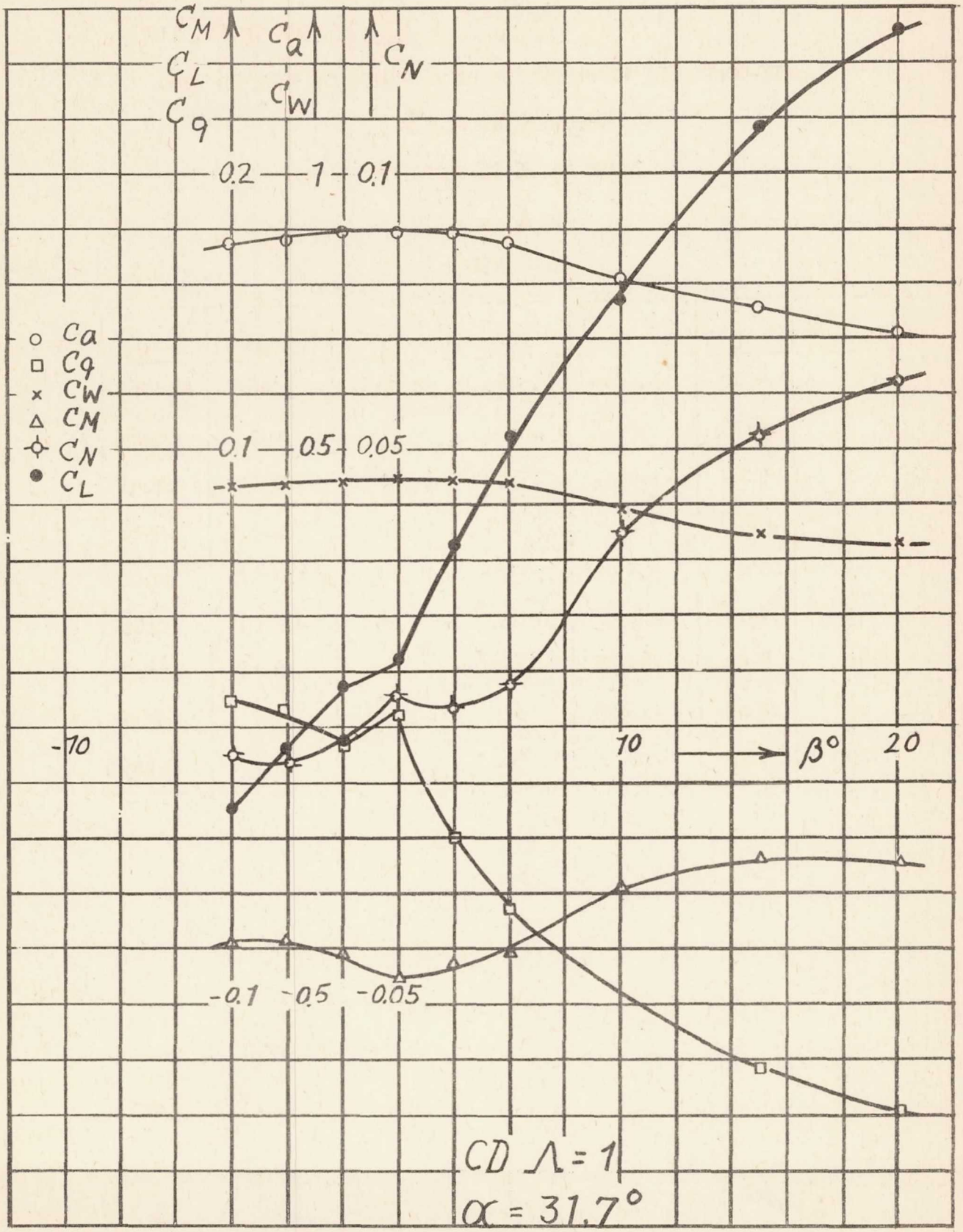

Chart 23.- 6-component measurement of a series of
Table 15.- tapered wings - triangular wings.

SIX-COMPONENT MEASUREMENTS OF A SERIES OF TAPERED WING

(Triangular Wing)

TABLE NO.16 TO CHART 24

CD Λ = 1

$\alpha = 34.89^{\circ}$

β°	c_a	c_q	c_w	c_L	c_M	c_N
-4	0.9210	-0.0045	0.5180	-0.0210	-0.0087	-0.0066
-2	.9175	.0048	.5160	-.0141	-.0053	-.0064
0	.9220	-.0007	.5186	-.0031	-.0083	-.0041
2	.9268	.0130	.5243	.0279	-.0105	.0026
4	.9500	-.0092	.5399	.0634	-.0217	.0092
6	.9414	-.0560	.5337	.1014	-.0229	.0166
10	.8360	-.0918	.4577	.1454	.0053	.0298
15	.7908	-.1538	.4295	.2171	.0044	.0288
20	.6675	-.1827	.3899	.2393	.0023	.0399

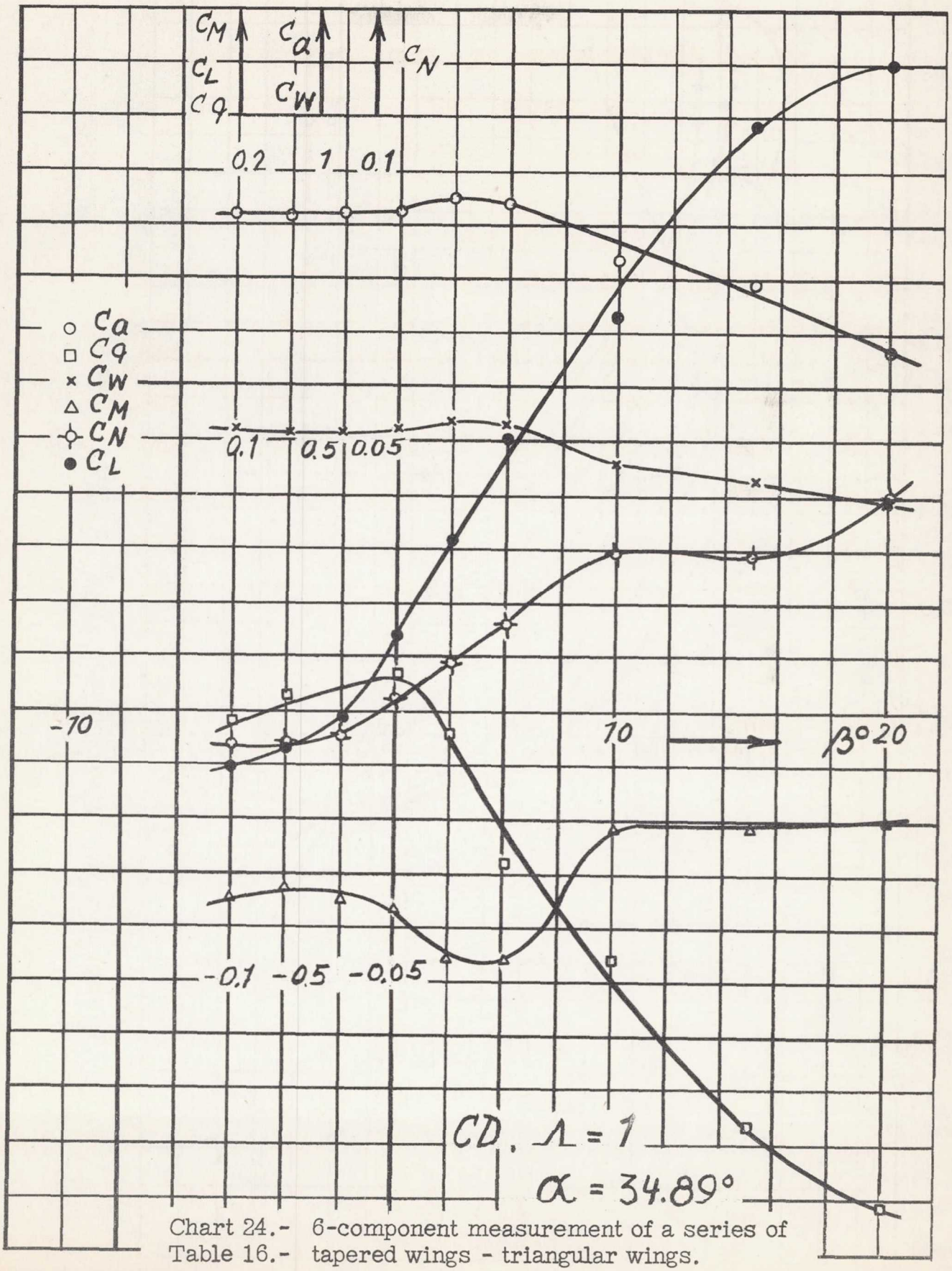

Chart 24.- 6-component measurement of a series of
Table 16.- tapered wings - triangular wings.

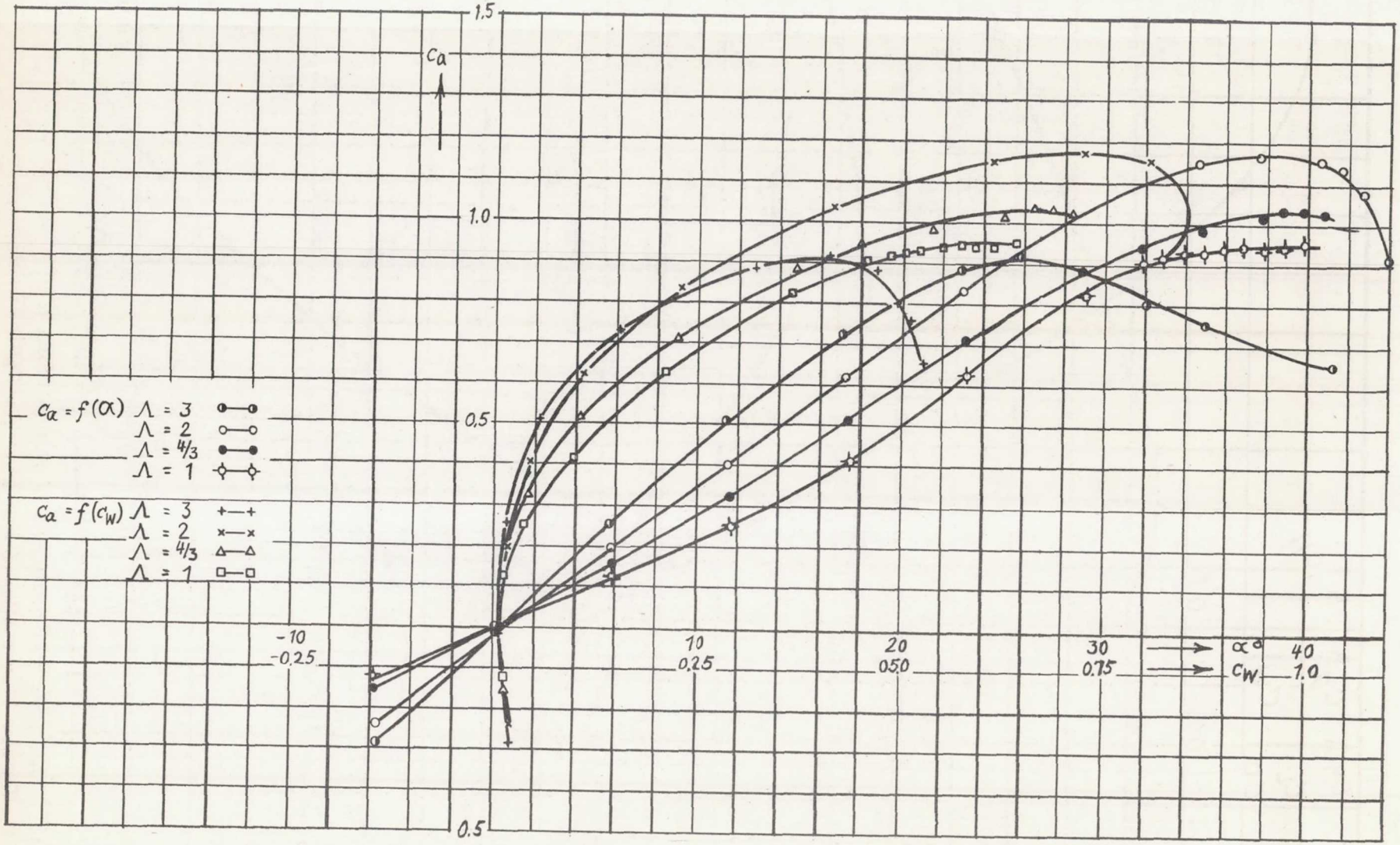

Chart 25.- $c_a = f(\alpha)$ and $c_a = f(c_w)$ - curves of a series of triangular wings.

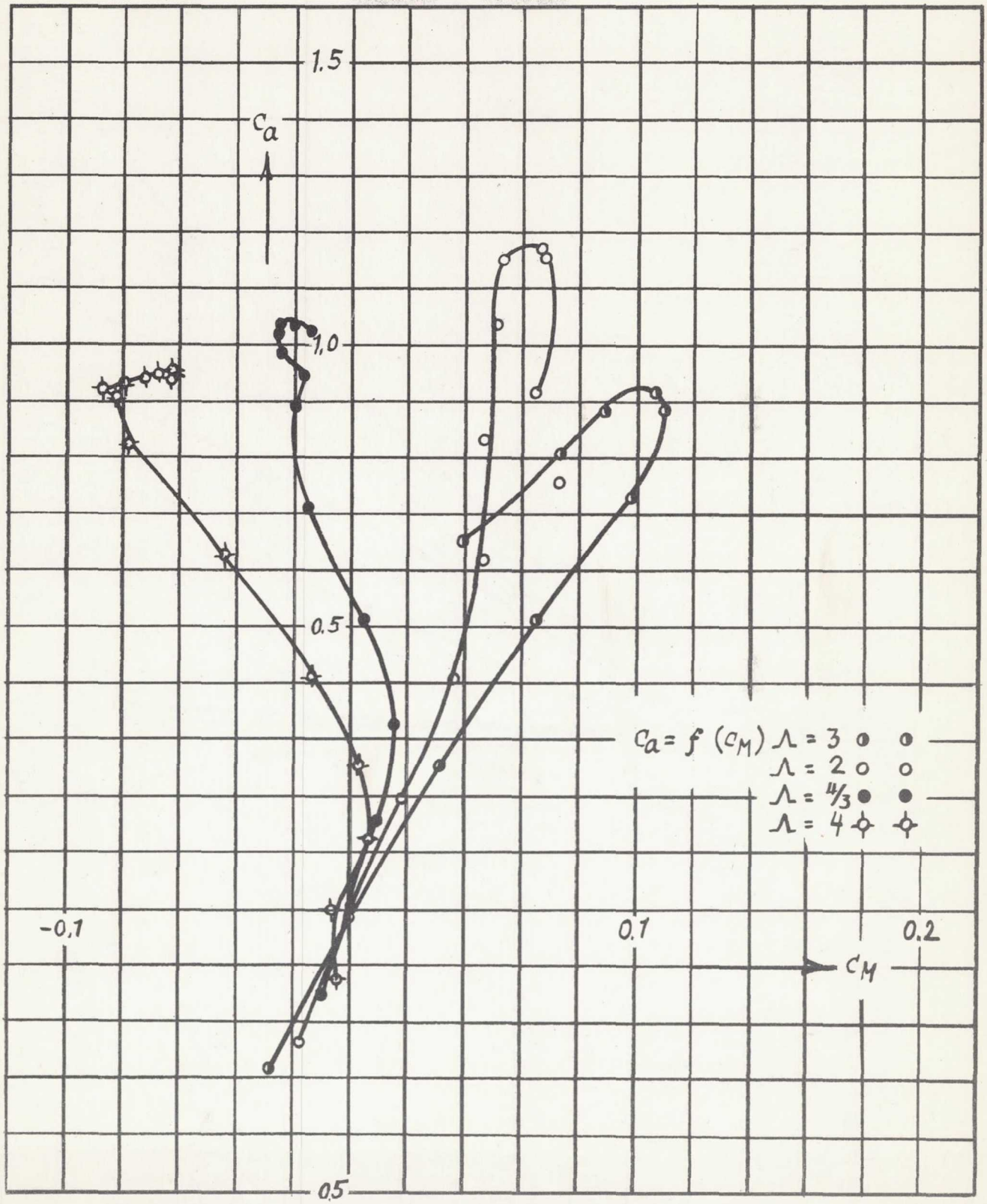

Chart 26.- $c_a = f(c_M)$ - curves of a series of triangular wings.

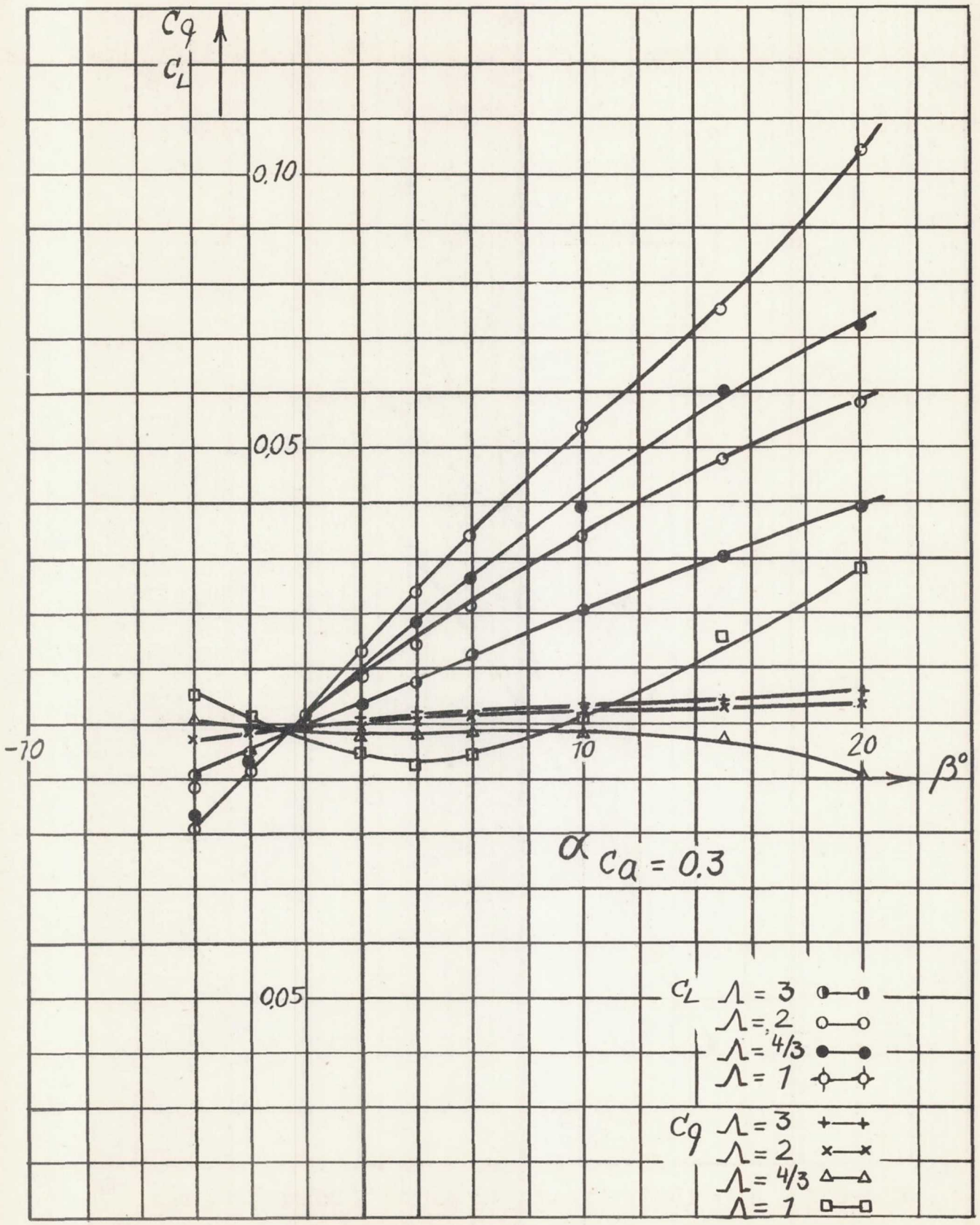

Chart 27.- c_L and c_q - curves of a series of triangular wings.

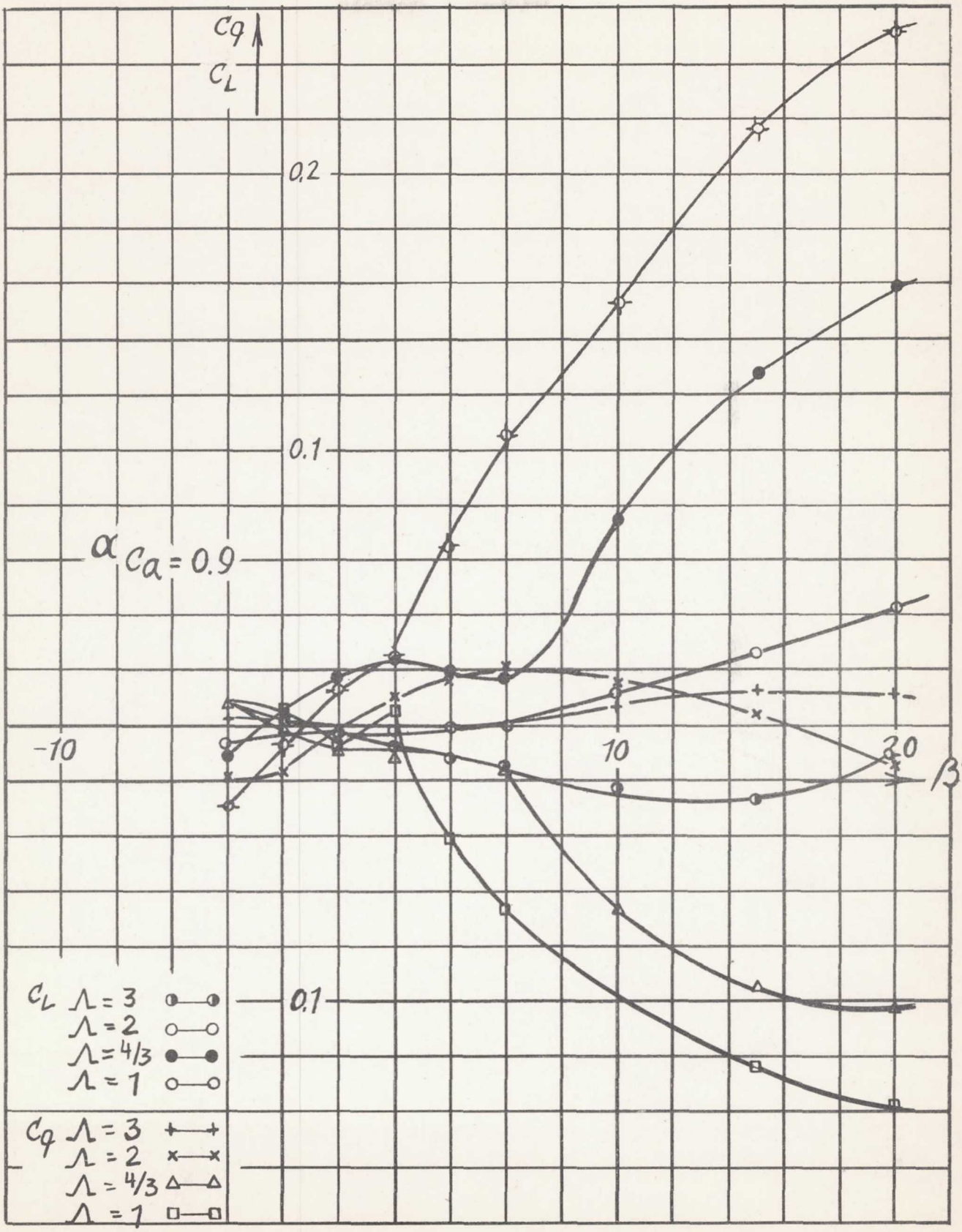

Chart 28.- c_L and c_q - curves of a series of triangular wings.